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OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 35 MAY 1913 NUMBER 5

The Society wishes to secure copies of the following issues of The Journal: August 1911, September 1911, October 1911, January 1912. These will be purchased at 25 cents apiece, provided they are in good condition.

SPRING MEETING

The program for the Spring Meeting at Baltimore, May 20-23, is published in this number, with information regarding railroad transportation. The headquarters will be at the Hotel Belvedere and the professional sessions and various social functions will both be held there.

The Society is fortunate in visiting Baltimore at a time when there are features in the way of engineering work of unusual interest. The high-pressure fire system recently completed will be shown to the visitors and a demonstration given of its possibilities in throwing large volumes of water. One of the important excursions will be over the Jones Falls conduits to inspect the newly completed sewage system and the sewage disposal plant at Back River, which is believed to be the largest and one of the most modern in the world. These engineering features, in addition to the natural attractions of the city, the opportunity for a sail in the harbor and for an all-day excursion to Annapolis, promise an occasion of rare enjoyment.

In accordance with the policy recently adopted by the Society,

the visiting members will share in the expense of the entertainment to the extent of paying for their fares, luncheons, and similar expenditures, rather than burdening local members with the necessity of raising funds for these purposes.

HOTEL RESERVATIONS

As it is confidently expected that there will be a large attendance at the meeting, it is very urgent that members should make their hotel reservations early. At this time of year there are always many visitors in Baltimore and accommodations are apt to be in demand. These reservations must be made personally in every instance, direct to the hotel.

Besides the Belvedere, accommodations may be secured in the Stafford, which is only three and a half blocks away from headquarters, and the Hotel Emerson, requiring an eight-minute ride on the trolley.

PROGRAM

Tuesday, May 20

Registration at Headquarters, Hotel Belvedere

Tuesday Evening

Membership Reunion and Informal Reception

Wednesday, May 21

Business Meeting, 9.30 a.m.

Business meeting. Report of tellers of election of members. Announcement of ballot on amendments to the Constitution relating to membership grades. New business may be presented at this session.

Reports of special committees on Myriawatt, Involute Gears, Standardization of Catalogues, Code of Ethics and National Museum

SIMULTANEOUS SESSIONS FOLLOWING BUSINESS MEETING

Professional Session

TEST OF A HYDRAULIC BUFFER, Carl Schwartz

THE PRESENT CONDITION OF THE PATENT LAW, Edwin J. Prindle

SHADING IN MECHANICAL DRAWING, Theodore W. Johnson

COST OF UPKEEP OF HORSE-DRAWN VEHICLES AGAINST ELECTRIC VEHICLES, W. R. Metz

Gas Power Session

Business meeting

PRESENT OPERATION OF GAS ENGINES USING BLAST-FURNACE GAS AS FUEL, Charles C. Sampson

Wednesday Afternoon

Demonstration of the high-pressure fire system at City Hall Plaza, and inspection of pumping station, followed by a sail about the harbor to inspect the water front, shipping facilities, and other features of interest

Wednesday Evening

Lecture, illustrated by lantern views: AROUND THE WORLD IN EIGHTY MINUTES, by Hon. O. P. Austin, Secretary, National Geographic Society

Thursday, May 22

Fire Protection Session, 9.30 a.m.

THE BALTIMORE HIGH-PRESSURE FIRE SERVICE, James B. Scott

NATIONAL STANDARD HOSE COUPLINGS AND HYDRANT FITTINGS FOR PUBLIC FIRE SERVICE, F. M. Griswold

DEBARMENT OF CITY CONFLAGRATIONS, Albert Blauvelt

ALLOWABLE HEIGHT AND AREA IN FACTORY BUILDINGS, Ira H. Woolson

THE PROTECTION OF MAIN BELT DRIVES WITH FIRE RETARDANT PARTITIONS, C. H. Smith

THE LIFE HAZARD IN CROWDED BUILDINGS DUE TO INADEQUATE EXITS, H. F. J. Porter

Thursday Afternoon

Inspection of sewage pumping plant, Jones Falls' conduits, and trip by trolley to sewage disposal plant at Back River

Automobile trip for ladies, about the city and suburbs, with tea served at the Country Club

Thursday Evening

Reception and dance. The Society will be the guest of the Engineers Club of Baltimore on this occasion

Friday, May 23

All day excursion to Annapolis, the capitol of Maryland, and to the U. S. Naval Academy, with a reception by Governor Goldsborough at the State House. After the reception the party will proceed to the Assembly Chamber where Admiral H. I. Cone, engineer-in-chief of the Bureau of Steam Engineering, U. S. N., will deliver an address upon the United States Experimental Station at Annapolis.

Luncheon will be served at the Carvel House. In the afternoon, there will be a band concert by the Naval Academy Band, and a dress parade at 6 o'clock, which may be witnessed by those finding it convenient to remain. It is expected that there will be hydroaeroplane flights by officers and men of the aviation school, and evolutions of the submarine boats stationed at Annapolis.

RAILROAD TRANSPORTATION NOTICE

Special concessions have been secured for members and guests attending the Spring Meeting in Baltimore, May 20-23, 1913.

The special rate of a fare and three-fifths for the round trip, on the certificate plan, is granted when the regular fare is 75 cents and upwards, from territory specified below.

a Buy your ticket at full fare for the going journey, between May 16-22 inclusive. At the same time request a certificate, *not a receipt*. This ticket and certificate should be secured at least half an hour before the departure of the train.

b Certificates are not kept at all stations. Ask your station agent

whether he has certificates and through tickets. If not, he will tell you the nearest station where they can be obtained. Buy a local ticket to that point, and there get your certificate and through ticket.

c On arrival at the meeting, present your certificate at the registration desk. A fee of 25 cents will be collected for each certificate validated. No certificate can be validated after May 23.

d An agent of the Trunk Line Association will validate certificates, May 21 and 22. No refund of fare will be made on account of failure to have certificate validated.

e One hundred certificates and round trip tickets must be presented for validation before the plan is operative. This makes it important to show the return portion of your round trip ticket at Headquarters.

f If certificate is validated, a return ticket to destination can be purchased, up to May 27, on the same route over which the purchaser came, at three-fifths the rate.

The special rate is granted only for the following:

The Trunk Line Association including:

All of New York east of a line running from Buffalo to Salamanca; all of Pennsylvania east of the Ohio River; all of New Jersey, Delaware and Maryland; also that portion of West Virginia and Virginia north of a line running through Huntington, Charleston, White Sulphur Springs, Charlottesville and Washington, D. C.

The New England Passenger Association (except via Bangor and Aroostook R. R. and Eastern Steamship Co.), including:

Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut, and that portion of New York east of a line running through Poughkeepsie and Troy.

MEETING IN GERMANY 1913

The official party for the trip to Germany, June 21–July 8, is now almost complete, all the ladies' reservations having been made and nearly all the members' reservations being taken. Committees have been appointed to care for various details in connection with the trip and plans are going forward smoothly.

Invitations have been received from a number of cities and firms which will make it possible for members who may so desire to extend their trip through Germany beyond the time scheduled on the official program. Among these are the city of Aachen, of historical as well as industrial interest, with its technical school and seismological station, metallurgical works, and textile and needle manufactures; the city of Freiburg-im-Breisgau, a trading center for the Black Forest, having considerable manufactures and a fine cathedral and university; and also the Prussian city of Breslau, one of Germany's chief commercial centers, containing numerous points of general interest. The Actiengesellschaft Ferrum of Zawodzie bei Kattowitz have also offered their hospitality.

Attention is called to the fact that it is expected that the ladies will participate in all the excursions in Hamburg, particularly the inspection of the port, shipbuilding yard, and Elbe tunnel. On the afternoon of Saturday, June 21, arrangements will be made for the ladies to visit the famous Hagenbeck Zoological Gardens in Stellingen near Hamburg. This is an addition to program as previously announced and as given herewith.

TENTATIVE PROGRAM

NEW YORK

Tuesday, June 10

10.00 a. m. The party sails on the Hamburg-American S. S. Victoria Luise (remodeled "Deutschland") from Hoboken. It will be advisable for members of the party to reach New York not later than June 9.

Representatives of the Verein deutscher Ingenieure will come on board at Cherbourg to receive the visitors.

HAMBURG

Thursday, June 19

Arrival in Hamburg.

Friday, June 20

11.00 a. m. Address: The Hamburg Harbor
11.00 a. m. to 1.00 p. m. Trip around the harbor
5.30 p. m. Reception in the Municipal Hall by the Senate of the city and by the Hamburg Section of the Verein deutscher Ingenieure

Saturday, June 21

10.00 a. m. Excursions
Group 1: Inspection of the Elbe tunnel and visit to the shipyards of Blohm and Voss
Group 2: Visit to the Vulcan yards and inspection of the Elbe tunnel

Sunday, June 22

10.00 a. m. Departure for Leipzig

LEIPZIG

Sunday, June 22

4.30 p. m. Arrival in Leipzig
8.00 p. m. Reception in the Crystal Palace

Monday, June 23

10.00 a. m. Formal meeting in the Municipal Hall
5.00 p. m. Concert under the direction of Mr. Arthur Nikisch in the Gewandhaus
7.30 p. m. Formal dinner in Central Theater

Itinerary of Official Tour in Germany

Tuesday, June 24

9.30 a. m. Scientific Lectures in the lecture room of the Architectural Exhibition
4.30 p. m. Inspection of the Monument of the Battle of Nations in commemoration of 100th anniversary of the battle of Leipzig, 1813
8.00 p. m. Festival in the Palm Garden

Wednesday, June 25

9.10 a. m. Departure for Dresden

DRESDEN

Wednesday, June 25

11.00 a. m. Arrival in Dresden
2.00 p. m. Gather at the Belvedere; automobile trip to the Saxon Switzerland (Bastei), walk to Rathen, by steamer to Pirna, by automobile to Dresden
8.30 p. m. Reception in the Municipal Building, tendered by the city of Dresden

Thursday, June 26

9.30 a. m. Excursion through Dresden
Group 3: Machine Laboratory of the Technical High School
Group 4: Seidel & Naumann Sewing Machine and Bicycle Factory
Group 5: Picture Gallery
12.30 p. m. Lunch in the Neustadt railway terminal
2.00 p. m. Departure for Berlin

BERLIN

Thursday, June 26

5.00 p. m. Arrival in Berlin
8.00 p. m. Reception in the Reichstag Building

Friday, June 27

9.30 a. m. Excursions
Group 6: Allgemeine-Elektricitäts Gesellschaft
Group 7: Siemens-Schuckert Works
Group 8: Bergmann Electrical Company
Group 9: Ludwig Loewe Company, Machine Tool Factory
Group 10: A. Borsig Locomotive Works in Berlin-Tegel
Group 11: Ladies' excursion and lunch
8.00 p. m. Formal dinner in the Zoological Garden

Saturday, June 28

2.30 p. m. Automobile trip to Potsdam and steamer trip on the Havel
7.00 p. m. Entertainment by the Berlin Local Section in Wannsee

Sunday, June 29

8.00 a. m. Departure for Düsseldorf, Rhine-Westphalia

DÜSSELDORF

Sunday, June 29

6.00 p. m. Arrival in Düsseldorf
8.00 p. m. Reception in the City Hall tendered by the city of Düsseldorf

Monday, June 30

9.00 a. m. Excursions

- Group 12: Duisburg works of the German Machine Works Company (50 participants)
- Group 13: Friedrich-Alfred steel plant of the Friedr. Krupp Co. in Rheinhausen (75 participants)
- Group 14: Machine Works of Thyssen & Co. in Mulhheim (Ruhr) (20 participants)
- Group 15: Gutehoffnung Steel Plant, Oberhausen Rheinland (40 participants)
- Group 16: Rhein Steel Works, Duisburg-Meiderich (50 participants)
- Group 17: In the morning the ladies inspect the city of Düsseldorf, and in the evening the welfare activities of Friedr. Krupp Co. in Essen
- Group 18: Afternoon inspection of the Duisburg-Ruhrort harbor by the members of groups 12 to 16, as well as others who apply for it

The other visitors will be afforded an opportunity to see the city of Düsseldorf

8.00 p. m. Banquet in the city concert hall of Düsseldorf, tendered by the Rhine-Westphalian Section of the Verein deutscher Ingenieure

Tuesday, July 1

9.00 a. m. Excursions

- Group 19: Haniel & Lueg, Düsseldorf-Grafenberg (50 participants)
- Group 20: Ernst Schiess Company, Düsseldorf (50 participants)
- Group 21: German Machine Works Company, Benrath plant, Benrath (50 participants)
- Group 22: Steel Works of Becker Company, Willich b./Krefeld (75 participants)
- Group 23: Trip into the mountains; inspection of the Elberfeld Lift railway, Barmer mountain railway, steel plant of Rich. Lindeberg Company, Remscheid-Hasten and the Mungsten Bridge
- Group 24: The ladies will inspect some installations in the city of Düsseldorf

4.30 p. m. Departure for Cologne. Members of Group 23 go from Remscheid direct to Cologne

COLOGNE

Tuesday, July 1

5.30 p. m. Arrival in Cologne

8.00 p. m. Informal gathering in the Zoological Garden of Cologne tendered by the Rhine-Westfalen Board. Trip on the Rhine with illumination of the city and cathedral

Wednesday, July 2

9.00 a. m. Excursions

- Group 25: Dye Works, formerly Friedr. Bayer & Co., Leverkusen (up to 100 participants)
- Group 26: Gas Engine Works, Deutz, Cologne-Deutz (up to 100 participants)
- Group 27: Machine Works Humboldt, Cologne-Kalk (up to 100 participants)
- Group 28: The ladies inspect the cathedral and city

8.00 p. m. Reception in Gurzenich tendered by the city of Cologne

Thursday, July 3

8.00 a. m. Departure by rail for Coblenz; thence on the Rhine by steamer to Rüdesheim, where there will be a festival on the banks, and thence by rail to Frankfort-on-Main

FRANKFORT-ON-MAIN

Thursday, July 3

6.00 p. m. Arrival in Frankfort-on-Main

8.00 p. m. Reception in the Palm Garden by the Frankfort Section of the Verein deutscher Ingenieure

Friday, July 4

11.30 a. m. Welcome by the city in Roemer. Luncheon

2.30 p. m. Excursions

- Group 29: Eastern port and gas works
- Group 30: Stockyards and gasholders
- Group 31: Refuse destroyer plant and filters
- Group 32: Inspection of the old city, Goethe house, Historical Museum
- Group 33: Visit to Saalburg

7.30 p. m. Independence Day celebration with the American colony

Saturday, July 5

10.30 a. m. Departure for Mannheim

MANNHEIM

Saturday, July 5

12.00 m. Arrival; lunch in the Friedrichspark

Excursions

- Group 34: Machine Works, Heinrich Lanz
- Group 35: Machine Works, Sulzer Bros. in Ludwigshafen
- Group 36: Brown-Boveri & Co., electric machinery

Group 37: Cement Works in Leinen and their welfare activities
Group 38: Benz & Co. Rhine Automobile and Motor Works Company
Group 39: Inspection of the port (steam flour mills in Ludwigshafen)

8.00 p. m. Reception of welcome

Sunday, July 6

11.00 a. m. Departure for Heidelberg

HEIDELBERG

Sunday, July 6

12.00 m. Arrival; lunch in the Stadtgarten, inspection of the Castle, concert in the Castle Restaurant

6.00 p. m. Dinner on the Molkenkur tendered by the Board of Reception

10.00 p. m. Trip to the Castle, illuminated by fireworks,. Given by the City of Heidelberg

11.00 p. m. Return to Mannheim

MANNHEIM

Monday, July 7

10.00 a. m. Departure for Munich

MUNICH

Monday, July 7

5.00 p. m. Arrival in Munich

8.00 p. m. Reception of welcome in the Hofbrauhaus

Tuesday, July 8

9.30 a. m. Inspection of the German Museum and its new building

3.00 p. m. Trip to the Sternberger See

8.00 p. m. Concluding exercises in the Rathhaus

STUDENT ACTIVITIES

Much splendid work is being done by the student sections of the Society, which cannot fail to develop a general interest in engineering affairs and attract interest in the opportunities afforded by The American Society of Mechanical Engineers for engineering service. As reported in the usual place in The Journal, two of the student branches have held exhibitions of engineering appliances which have involved a great deal of work in their preparation and which reflect much credit upon the students through the good judgment displayed in the selection of apparatus.

One of these exhibitions was held at the University of Wisconsin, Madison. Certain of the agricultural students coöperated

with the members of the student section, and the exhibition was given at the new stock pavilion of the agricultural department, which has a stadium with an arena 170 by 70 feet. Floor space was sold to the dealers, the money received being used to cover the necessary expenses. The exhibition was advertised and brought prominently before the people of the state, the idea being that many people were ignorant of the application and operation of internal-combustion engines and that a show of this type of engine would be of real educational value. The exhibits included tractors, automobiles, farm engines and general utility gas engines, and motor boats.

The second exhibit mentioned was held at New Haven at the Mason Laboratory of Mechanical Engineering, and was arranged by the student branches of the different societies in the engineering department of the Sheffield Scientific School. It consisted of the regular apparatus of the laboratory, so arranged as to be demonstrated for the benefit of the visitors, supplemented by contributions from some twenty manufacturing firms. There were in all 85 different exhibits and student operators were present to demonstrate the working of the apparatus and explain its uses to those interested. The exhibit was so successful that between 2500 and 3000 attended during the three evenings when the apparatus was displayed.

Another event of interest was the annual meeting of the student branch of the University of Kansas at Lawrence. This is the fourth annual meeting to be held, and started with a session in the morning at which an opening address and professional papers were given. In the afternoon, there was a second professional session, and the affair closed in the evening with a banquet.

The reports which have come to the Society from the various student branches throughout the winter season have shown that many meetings have been held in the different colleges which were of real engineering value, the students often being addressed by prominent speakers. Such meetings must demonstrate to young engineers the desirability of getting together, and lead in after life to an association with others in their own and related lines of activity which is always beneficial.

A student branch has recently been formed at the University of Iowa, making twenty-eight in all now connected with the Society.

CURRENT AFFAIRS OF THE SOCIETY

Among the many bequests contained in the will of John Fritz, Honorary Member and Past-President, who died on February 13, 1913, the first to be mentioned were gifts to the Society. One of these, a fine mahogany hall clock, standing nearly eight feet high and valued at fifteen hundred dollars, has been placed in the rooms of the Society. It was presented to Mr. and Mrs. Fritz by their numerous friends on the occasion of Mr. Fritz's seventieth birthday, and bears the inscription, "Oh! Time deal gently with our loving friends, John and Ellen M. Fritz, August 21st, 1892, Bethlehem, Pa." Another and equally valuable bequest is the handsome silver loving cup presented to Mr. Fritz by Irving M. Scott, builder of the U. S. battleship *Oregon*, in recognition of the high quality of the product furnished by Mr. Fritz for the vessel. The cup, which is now in the Society's possession, is essentially artistic in the simplicity of its design and bears a map of the famous run made by the battleship in 1898 from Puget Sound to Key West, a distance of 14,712 miles, in less than two months. Upon it are inscribed the words, "To John Fritz on his Eightieth Birthday. The Builder of the West greets the Genius of the East. The Oregon's performance glorifies the steel of Fritz."

In addition to these gifts, the executors of the Fritz estate have placed in the custody of this Society his certificates of Honorary Membership in the technical and learned societies of the world, greetings from organizations, etc., and several medals which Mr. Fritz received. Among these the most precious are the original bronze medals presented by the John Fritz Medal Committee, together with the album of autographs of the 750 donors of the fund which established this medal; also the Bessemer gold medal and the Elliott Cresson gold medal. The portraits have also been received of W. R. Jones, Alex. L. Holley, and the much-prized autographed group of Mr. Fritz, Ambrose Swasey and S. T. Wellman. All these mementos will be preserved by the Society, and should serve as an inspiration to young men for earnestness of purpose and lofty ideals.

LICENSING ENGINEERS

The Conference Committee of the National Engineering Societies held a meeting during the month, to which were invited also representatives of the National Electric Light Association, the American Gas Institute, and the Institute of Consulting En-

gineers, to consider the propriety of preparing a bill for registering engineers, which should be offered to the Legislature of New York and other States should these bodies consider legislation in this matter essential. It was the sense of the conference that such a bill be prepared, and this recommendation has been made to the councils of the respective organizations represented.

UNITED ENGINEERING SOCIETY

At a recent meeting of the Board of Trustees of the United Engineering Society, the wish of the trustees that each governing body of the Founder Societies shall be completely informed both of the policies and of action taken at its meetings was expressed by a vote, inviting any officer or member of the governing body of a Founder Society to be present at any meetings of the Board, except such as may upon request of a member, supported by a majority vote of the Board, be conducted in executive session.

CALVIN W. RICE, *Secretary*

NEW YORK MEETING, APRIL 8

In this issue is published a collection of thirteen papers upon the subject of Steel Car Design, given at the New York meeting of the Society on April 8. This meeting was one of the most largely attended monthly meetings ever held, and the interest in the subject was evidenced by the presence of many engineers and railroad men from outside the city. It further demonstrated the success which is being attained by the sub-committees appointed by the Committee on Meetings to arrange for the presentation of papers by the foremost authorities in different fields of activity. The papers for this meeting were secured through the solicitation of the sub-committee on Railroads, E. B. Katte, Chairman. At the invitation of the New York Local Committee, which coöperated with the Railroad Committee, the session was held at the time for the regular monthly meeting in New York.

It will be noted that the papers were all brief, each one treating of one definite subject upon which the writer is a specialist. This method of presentation of a subject is to be contrasted with the older and more familiar use of long papers, written by a single author and covering the whole field. While each method may have its advantages, it cannot be doubted that the former plan is more efficacious in arousing a general interest in the subject. Each man in turn presents his one point in a way

to direct the attention of the audience through his personality, making sure the sustaining of interest, as was the case at this meeting.

Following the presentation of the papers was a brief discussion by George Gibbs, John A. Pilcher, Wm. F. Kiesel, Jr., and S. A. Bullock. It is expected that some additional contributions will be received and publication of the discussion is therefore deferred until a later issue.

DINNER IN HONOR OF PROFESSOR HOLLIS

On Tuesday evening, April 29, a dinner was given at the Boston City Club by members of the Boston Society of Civil Engineers, the American Institute of Electrical Engineers, and of this Society, in honor of the appointment of Prof. Ira N. Hollis of Harvard University to the presidency of Worcester Polytechnic Institute. Dr. Richard C. MacLaurin, President of Massachusetts Institute of Technology, Dr. A. Lawrence Lowell, President of Harvard University, and other distinguished educators were present.

At the conclusion of the dinner papers illustrated by lantern slides were presented, one upon Some Phases of the Development of the Grand Central Terminal by George W. Kittredge, chief engineer of the New York Central lines, and another on Problems in Local Transportation, by Matthew C. Brush, second vice-president of the Boston Elevated Railway Company.

DEATH OF HONORARY MEMBERS

During the past few months, the Society has lost by death a number of its Honorary Members. An account of the career of two of these, John Fritz and Sir William Arrol, appeared in the April issue, and biographies of Carl Gustaf Patrik de Laval and Victor Dwelshauvers-Dery are given herewith.

CARL GUSTAF PATRIK DE LAVAL

On February 3 of this year there passed away an engineer of world-wide fame, Dr. Carl Gustaf Patrik de Laval, whom we are proud to have numbered among our honorary members. He was in his sixty-eighth year, in the full possession of those faculties, the conscientious use of which in the service of mankind had placed him in the front rank of his profession.

Dr. de Laval was born at Blosenberg in the Province of Dalecarlia, Sweden, on May 8, 1845, of a family of soldiers whose French ancestor rode to fame with Gustavus Adolphus. The inherited qualities of courage, alertness, endurance, and close observation, he carried into that nobler warfare with stubborn materials and elemental forces in which the wit of man conquers not by destruction but by making their energies his willing instruments.

In his eighteenth year he entered the technical department of the University of Upsala, and was graduated with distinction three years later, carrying with him, indeed, the highest honors in every department. His first position was with the Stora Kopparberg Company of Bergslad as a draftsman, but considerations of health forced him to give up this confining occupation for one with more opportunities for outdoor exercise. He accordingly decided to return to Upsala for further study, and in 1872 received the degree of Doctor of Philosophy. In the same year he re-entered the employ of the copper company and made for them investigations in the manufacture of sulphuric acid. Upon completion of this task Dr. de Laval resigned his position for a ven-

ture of his own, a glass factory at Falun, which, however, unfortunately failed, leaving him heavily in debt.

He then entered the employ of the Klosterverken Iron Works as engineer, and it was during his connection with this company and while carrying on his daily duties in the works that he developed from a crude German device the centrifugal cream separator which has made his name a household word on the dairy farms of the world. So absorbed did he finally become in its perfection that he gave up his position in order to devote his entire time to it. When it finally worked to his complete satisfaction he endeavored to secure in Stockholm the financial assistance needed to place it on the market, but it was only by extreme persistence that he was able to obtain even a small loan. Its manufacture proved an immediate success and it was not long before the Separator Company, Limited, was on a secure financial basis.

The cream separator called, however, for some means to drive it at the high speed required, and Dr. de Laval attempted to apply to it the ancient principle of Hero of Alexandria, driving a reaction wheel by two steam jets normal to the direction of rotation. This in its turn brought the inventor face to face with troubles with transmission and shafts rotating at high speeds, which he attempted to overcome by using a special bearing, lubricated by the oil acted on by centrifugal force, together with a high-speed worm-drive transmission. For many years cream separators were made with direct steam drive, but their economic efficiency proved to be poor. At the end of the eighties de Laval was ready with the first steam turbine, embodying practically all the features which have since become familiar to every engineer, such as conversion of the energy of high-pressure steam into velocity by means of the de Laval nozzle, the use of a wheel running at a very high speed, and the flexible shaft running at a speed far exceeding the critical speed. The new prime mover, running at what was then considered a frightful speed of some 24,000 r.p.m., which had to be reduced to one-tenth of it for driving the separators, did not prove convenient for this purpose and became the basis of a separate industry.

Dr. de Laval was not the type of man to rest content with one success and to devote his time to the management of his existing concerns, even though that clearly appeared to be the easiest way to wealth. In looking for new things to which to turn his in-

ventive genius, de Laval started the manufacture of milking machines, and when this enterprise proved unsuccessful, devoted his time and fortune to discovering a new process for treating low-grade Swedish zinc ores. This venture, which gave some interesting scientific results, proved so disastrous to him financially, that in 1908, at a time when the Separator Company in which de Laval was originally one of the largest shareholders, was more prosperous than ever before, his affairs were in such a state that the company voted him a pension of 12,000 krones.

Large rewards came to him in wealth and honor, but, instead of hoarding his gains, he saw in them only the means and the incentive for further work for the benefit and advancement of mankind. In the ethical, no less than in the intellectual sense, he deserves the title of a great engineer. Dr. de Laval was a member of the Swedish House of Lords and during his lifetime received n any foreign orders and distinctions.

E. D. M.

VICTOR DWELSHAUVERS-DERY

On March 15, Victor Auguste Ernest Dwelshauvers-Dery, professor emeritus of the University of Liège, died in Belgium, bringing to a close a long life of service in the field of engineering research and investigation. Professor Dwelshauvers-Dery was born at Dinant on April 25, 1836, and receiving his early education at home, entered at the age of seventeen a small college in Brussels in which he gave special attention to the study of higher and applied mathematics. In 1861 he was graduated from Liège University with the diploma of mechanical engineer and in the same year accepted from his alma mater the position of lecturer in mechanics. The university's recognition of his talents was soon justified by his rise to the chair of professor of mechanics, a position which he held for many years.

The important thing to which Professor Dwelshauvers-Dery immediately directed his attention was the establishment of an engineering laboratory where theory might be compared with practice. He established in the university courses of lectures covering in detail the theory and construction of the steam engine and the economics of steam raising, and his object in securing a laboratory was the investigation of certain discrepancies between steam engine theory and practice. He began his efforts toward this end as early as 1870, but it was not for ten years

that they were even partially successful, a grant being then allowed him for the purchase of a steam engine, which, however, he had to run at his own expense outside of the university premises. In 1893 the laboratory was finally established according to Professor Dwelshauvers-Dery's original plan, and he immediately began there his experiments with steam consumption and steam jacketing, gathering about him in this work many brilliant students. The effect of high compression on steam economy was one of the earliest matters to be investigated, for which Professor Dwelshauvers-Dery designed an experimental steam engine where he was able to vary at will the steam distribution, the governing and also the degree of compression. From these experiments he obtained his theories on steam compression which are widely known. His views on the phenomena due to steam jacketing under most varying conditions, one of his favorite subjects, were presented at a meeting of the Institution of Mechanical Engineers and are published in their proceedings for 1905.

In 1900 Professor Dwelshauvers-Dery was invited to become rector of the university and was obliged in undertaking these heavy duties to interrupt his work in the laboratory. Three years later he retired from public life, but his advice and collaboration were still given freely wherever asked and he contributed extensively to the Belgian and French technical press.

Professor Dwelshauvers-Dery was honored in 1888 by the award by the Institution of Civil Engineers of the Watt Medal and Telford Prize for his paper on the Steam Engine Governor, and in 1889 he shared with Donkin a prize for investigations on the thermal action of walls of a steam engine cylinder. That his teachings were widespread in their effect is evidenced by the fact that the establishment of the laboratory in University College, London, was due to the work which he had done at Liège. He was a corresponding member of the British Association, the Institut de France, the Société Industrielle de Mulhouse, and the Société d'Encouragement pour l'Industrie Nationale, a commander of the Leopold Order, and a knight of the Legion of Honor.

THE MYRIAWATT AS A UNIT OF ELECTRIC POWER

In June 1912 a paper by H. G. Stott and Haylett O'Neill was read at the annual convention of the American Institute of Electrical Engineers which proposed the use of "the myriawatt as a unit of power" in connection with steam and gas engine units, steam boilers, etc. The myriawatt is equivalent to 10,000 watts and very nearly parallels the commonly accepted term boiler horsepower, being 2 per cent larger than this unit. Following the presentation of the paper upon the myriawatt the Council of The American Society of Mechanical Engineers appointed a committee to meet with the Standards Committee of the American Institute of Electrical Engineers and to report upon the subject of the myriawatt and its use in place of the older term of boiler horsepower. In The Journal for February 1913 the committee reported in favor of the myriawatt, and the original paper explaining its use was reprinted. The subject is now open for discussion and two contributions follow.

DISCUSSION

William Kent. The units of electric power in common use are the watt and the kilowatt (or 1000 watts). We do not use the dekawatt or the hectowatt (10 or 100 watts). Why should we use the myriawatt (10,000 watts)?

There is a general tendency to discontinue the use of unnecessary units; thus in English measures we have in common use the inch, the foot, and the mile, and in engineering we do not use the yard (except the cubic yard), the rod, the furlong or the league. We use the pound and the ton, and have abandoned hundred weights and quarters. In metric measures the kilometer, the meter and the millimeter, the gram, the kilogram and the milligram are commonly used, while the hectometer, the dekameter and the decimeter, the hectogram, the dekagram and the decigram are rarely seen. The gallon, a useless unit, is slowly being replaced by the cubic foot, and the grain, another useless unit, is being replaced by a decimal fraction of a pound. There

are two reasons for the tendency to discontinue the use of certain units: *a* because the average man cannot think in a great variety of units, and *b* because the use of fewer units tends to economize time in calculations. If electrical engineers wish to discontinue the use of the term horsepower, and to use the kilowatt as the unit of both electrical and mechanical power, it is because they think in kilowatts and wish to avoid the trouble of converting kilowatts into horsepower and vice versa. There is no objection to their doing this if they see fit, but there seems to be no good reason why they should use the myriawatt instead of the kilowatt. The mechanical engineer, however, thinks in horsepower. He finds the term in all his reference books and other engineering literature, and he will not take the trouble to express quantities of mechanical power in either kilowatts or in myriawatts if he can possibly avoid it.

It is suggested that the myriawatt be used for the input and the kilowatt for the output in computations of efficiency. To do this would be to violate the usual custom, which is to define efficiency ratio as the quotient of output divided by input, both numerator and denominator being expressed in the same unit, and to multiply this ratio by 100 or shift the decimal point two places to the right, to obtain the efficiency as a percentage. According to the suggestion of Messrs. Stott and O'Neill, the quotient of output in kilowatts divided by input in myriawatts has to be divided by 10 to obtain the efficiency ratio or multipled by 10 to obtain the percentage.

The chief objection the mechanical engineer will have to using the kilowatt or its multiple, the myriawatt, as a unit of mechanical power instead of horsepower is that the horsepower is directly derived from the two fundamental units, the foot and the pound (1 h.p. = 550 ft-lb. per sec., 33,000 ft-lb. per min., or 1,980,000 ft-lb. per hr.); while the kilowatt is 1000 times the product of volts, amperes and power-factor, no one of these being related to the foot or the pound, but requiring to be measured by indicating instruments, such as the voltmeter, ammeter, and wattmeter. Of course we can obtain the kilowatt from the mechanical units by using the conversion factor 1 kw. = 737.56 ft-lb. per sec., 44,254 ft-lb. per min., or 2,655,200 ft-lb. per hr., but who wishes to use such conversion factors when he can use the ones which he easily remembers, connecting the horsepower and the foot-pound. There might be a better mechanical unit of power

than the horsepower, say a "kilovim," 1000 ft-lb. per sec., 60,000 ft-lb. per min., or 3,600,000 ft-lb. per hr., but the old unit is so entrenched in custom and in literature that it cannot be done away with. The horsepower is here to stay and we can no more eliminate it than we can eliminate the gallon, whose only excuse for existing is that it is established by custom. The gallon is 231 cu. in. in the United States, and 277.274 cu. in. in England and in Canada, but bad as they both are, we cannot get rid of them.

There are three different kinds of units used by engineers in measuring quantities of energy or of power (rate of transmission or conversion of energy), namely, mechanical, electrical, and heat units. Mechanical energy is measured in foot-pounds, using a 2-ft. rule and a platform scale; mechanical power in foot-pounds per second or in horsepowers. Electrical power is measured in volt-amperes or in kilowatts by means of electric meters, and electrical energy is measured as the product of these units into units of time, such as seconds or hours. Heat energy is measured in British thermal units, and is the product of weight in pounds, specific heat and difference of temperature. Mechanical energy may be transmitted by a shaft or belt, and may be stored in a revolving flywheel, or, as potential energy, in a weight raised to a height above the earth, or in a compressed spring. Electric energy is transmitted as an electric current on a wire, and is stored in a storage battery. Heat energy is transmitted by radiation, conversion or conduction, and is stored in a mass of material raised to a high temperature. These three kinds of energy naturally are and should be measured in different kinds of units. Since the three kinds of energy can be converted one into another and the equivalent of one in terms of the other is known with considerable accuracy, the units may also be converted into one another by the use of certain numerical factors of conversion. Thus kilowatts may be converted into foot-pounds per second or into heat units per second; but there is no more reason why we should express the power transmitted through a shaft in kilowatts than why we should express it in heat units. When heat energy is converted into mechanical energy, and that into electric energy, we need the three kinds of units to express the amount of energy in each of its three forms, if we wish to convey to others a clear idea of the quantity of energy that is measured in each form, and to show the several losses, such as heat lost in the chimney, steam lost by cylinder condensation and discharged into the con-

denser, friction of engine, friction, windage and electrical losses in the generator. It may be convenient in some cases to tabulate all the losses, from the coal to the switchboard, in heat units, and to convert each expression of energy, measured in whatever form, into heat units, so as to make a heat balance, but there seems to be no occasion ever to record any of the quantities between the coal and the generator in kilowatts.

The following conversion table is practically all that is needed in computations of the different kinds of power and energy:

Kind of Unit		
Mechanical	1 h.p.	=0.7457 kw. =2546.5 B.t.u. per hr. =550 ft-lb. per sec.
Electrical	1 kw.	=1.3410 h.p. =3415.0 B.t.u. per hr. =737.56 ft-lb. per sec.
Heat	1 B.t.u.	=1/180 of heat of 1 lb. water between 32 deg. and 212 deg. fahr. =777.54 ft-lb.
	1 unit of evaporation	=970.4 B.t.u.

Messrs. Stott and O'Neill's chief reason for introducing the term myriawatt seems to be that they wish to substitute it for the boiler horsepower as a measure both of performance or capacity, and of rating for commercial purposes. Let us consider what the boiler horsepower is. It is not a measure of energy, either mechanical, electrical or thermal; it is merely a commercial term, applied to stationary boilers only, never to locomotive or marine boilers. It has two meanings: (*a*) a measure of the size of the boiler, that is, the extent of heating surface, it being customary to call 10 sq. ft. of heating surface a horsepower; (*b*) a measure of performance, merely the quotient of the equivalent pounds of water evaporated from and at 212 deg. per hr. divided by the arbitrary figure 34.5. The term originated many years ago in England, when very low pressures were used. It was customary to say that a boiler required to have 1 sq. yard of heating surface, 1 sq. ft. of grate surface, and to evaporate 1 cu. ft. of water, to develop 1 h.p. in a steam engine. The origin in this country of a more modern definition was probably due to Prof. R. H. Thurston, in connection with the steam boiler trials in the American Institute Fair in 1871. Steam pressures at that date averaged about 70 lb. gage, feedwater temperatures were variable, averaging about 100 deg., and the average engine was assumed to require about 30 lb. of steam per hour per horsepower. These figures were then combined in the definition of the horsepower of a boiler, not as a measure of power it could actually produce

in connection with any given engine, but merely as a unit for comparing one boiler with another. After that date it became customary to regard 15 sq. ft. of heating surface per h.p. the measure of size or rating of a boiler, but in later years competition among boiler makers brought the figure down to 12 sq. ft. and finally to 10 or less. The judges of the boiler trials at the Centennial Exhibition in 1876 used in their report the same definition of the boiler horsepower, 30 lb. per hour from feed at 100 deg. into steam at 70 lb. gage pressure, and the first committee of The American Society of Mechanical Engineers on boiler trials in 1884 reaffirmed it, but added to it these words: "which shall be considered to be equal to 34½ units of evaporation, that is, say, to 34½ lb. of water evaporated from a feedwater temperature of 212 deg. fahr. into steam at the same temperature. This standard is equivalent to 33,305 thermal units per hour." The committee of 1899 also readopted the 34½ lb. standard, but as the definitions of the heat unit and of the unit of evaporation have since been slightly modified, the heat equivalent of the boiler horsepower became $34\frac{1}{2} \times 970.4 = 33{,}479$ thermal units per hour.

The present Committee on Power Tests of the Society in its preliminary report,[1] recognizing the validity of the objections to the boiler horsepower in these days of high-pressure steam and of steam turbines, abandoned it as a standard unit of boiler capacity, and adopted as the standard unit "1 lb. of water evaporated into dry steam from and at 212 deg. per hour," and put in a foot-note the statement "a subsidiary unit which may be used for stationary boilers is a 'boiler horsepower,' or 34½ lb. of water evaporated from and at 212 deg. per hour, i.e. from water at 212 deg. into steam at the same temperature."

Messrs. Stott and O'Neill have taken up this old and discredited unit, which never was a scientific unit but only a commercial one, modified it about 2 per cent, so that it is no longer 34½ lb. but 35.192 lb., equivalent to 34,150 B.t.u. per hour, and instead of giving it a name which will show that it has some relation to a steam boiler, they call it a myriawatt, which is nothing more nor less than 10 kw., an electrical unit, neither a unit of thermal capacity nor of mechanical power. They go still further and ask us to adopt this myriawatt as a unit for turbines, waterwheels, gas engines, and gas producers, for all of which the boiler horse-

[1] The Journal, November 1912, p. 1706.

power was never designed and never used. They ask us to measure input in myriawatts and the output in kilowatts, and to change the meaning of efficiency, so that it is no longer output divided by input in the same units, but output in kilowatts divided by input in myriawatts, and this quotient divided by 10 to get the efficiency ratio, or multiplied by 10 to get the efficiency percentage.

In former times when computing a boiler test, we found the equivalent evaporation in pounds per hour and divided it by 34.5 to obtain the boiler horsepower; now we must divide by 35.192, or multiply by 970.4 and then divide by 34,150 to get the myriawatts. In former times when computing the test of a waterwheel, we obtained the foot-pounds of work done per minute by a Prony brake and compared it with the foot-pounds of potential energy of the water, dividing the former by the latter gave the efficiency, or dividing each by 33,000 gave the horsepower, developed and potential. Now we must convert the foot-pounds per minute into myriawatts, and we need a new conversion table for the relation of myriawatts to other kinds of units, such as is given in Messrs. Stott and O'Neill's paper. The following is an example showing the calculations required in connection with the test of a steam-electric plant in order to obtain the several efficiencies. The old method and the proposed method are shown in parallel columns. A careful examination of the calculations given in the last column will show that the myriawatt method has no advantage whatever over the old method, but on the contrary it is more inconvenient and troublesome:

	B.t.u. Method	Myriawatt Method
Coal, lb. per hr.	1000	
Coal, B.t.u. per lb.	14000	$\div 34150 = 0.40996$ mw.
Steam, lb. per hr.	9000	
Feedwater temperature, deg. fahr.	110	
Steam pressure gage, lb.	150	
Factor of evaporation	1.151	
Equivalent evaporation, lb. per hr.	10,359	
Equivalent evaporation per sq. ft., heating surface per hour	3.45	
Equivalent evaporation per lb. coal	10.36	
Boiler horsepower, 10,359 ÷ 34.5	300	$\frac{10359 \times 970.4}{34.50} = 294.1$ mw.
Pipe leakage and radiation, 2 per cent, lb.	180	
Steam to engine, lb.	8820	

Heat per lb. steam from 110 deg. fahr. to 150 lb., B.t.u.	1117	÷34150 = 0.032709 mw-hr.
I.h.p. of engine	600	×0.07457 = 44.742 mw.
Kw. at switchboard	380	380 kw.
Steam per i. h.p. per hr., lb	14.70	×13.41 197,13 lb. per mw-hr. (engine)
Steam per kw-hr., lb. $\frac{8820}{380}$	= 23.21	23.21 lb. per kw-hr. (switch-board)

Per Cent Efficiency

$\frac{\text{kw.}}{\text{I h.p.}}$ $\frac{380 \times 1.341}{600}$	= 84.93	$\frac{380 \times 10}{447.42} = 84.93$
$\frac{\text{kw.}}{\text{steam}}$ $\frac{380 \times 3415}{8820 \times 1117}$	= 13.17	$\frac{380 \times 10}{8820 \times 0.032709} = 13.17$
$\frac{\text{I h.p.}}{\text{steam}}$ $\frac{600 \times 2546.5}{8820 \times 1117}$	= 15.51	$\frac{44.742}{8820 \times 0.032709} = 15.51$
$\frac{\text{Steam to engine}}{\text{coal}}$ $\frac{8820 \times 1117}{1000 \times 14000}$	= 70.37	$\frac{8820 \times 0.032709}{1000 \times 0.40996} = 70.37$
Boiler and furnace $\frac{10359 \times 970.4}{1000 \times 14000}$	= 71.80	$\frac{10359 \times 970.4 \div 34150}{1000 \times 0.40996} = 71.80$
$\frac{\text{kw.}}{\text{coal}}$ $\frac{380 \times 3415}{1000 \times 14000}$	= 9.27	$\frac{380 \times 10}{1000 \times 0.40996} = 9.27$

The authors of the paper will not succeed in persuading the mechanical engineering profession to adopt the myriawatt, but they can introduce it into literature, to the confusion of engineering students of the future. Already the Electrical Review of Chicago[1] has editorially commended it, saying, "the suggestion is an admirable one and will appeal to every electrical engineer. The suggestion has been adopted by a joint committee of the American Institute of Electrical Engineers and The American Society of Mechanical Engineers, and this should guarantee its gradual introduction into general practice." The Review apparently delights in suggestions, for in the same editorial it says, "another suggestion has been to apply the name of 'kelvin' to a unit representing 10,000,000 joules, which will give a unit of commercial size. A joule represents 10,000,000 ergs. This unit would represent 2.78 kw-hr."

On the other hand the Electrical Review of London[2] makes fun in an editorial of the myriawatt. It says, "What we cannot understand, however, is why in the name of common sense they want to measure the input by a unit ten times that used for the

[1] February 1, 1913.

[2] January 31, 1913.

output. Have our cousins lost their traditional sense of humor?" It is evident that our English friends will not adopt the myriawatt, and if our writers and text books adopt it, we shall have another instance of the two English speaking nations using different technical terms and definitions.

It is easy to make suggestions for new units, and it is easy for an eloquent and forceful man to persuade a committee to adopt them. It is easy also for newspaper men, college professors and text-book writers to put them into literary use. But it is hard to do away with them. Many years ago some one invented the term "poundal" as a unit of force. It was accepted by practically every text-book writer on physics and mechanics. It was taught in the colleges to thousands of students, wasting their time and confusing their minds, but it was never adopted by any engineer in his practice, and only within the last five years have we seen signs that it is getting into disrepute among text-book writers. In 1876 an international committee of metallurgists forced upon the literary world a definition of steel which was not known in commerce, and invented the terms ingot iron, ingot steel, weld iron, weld steel, which immediately began to infest metallurgical literature. They remained in the papers and text books for many years, but commerce never adopted them, and they have now practically died out from literature. About 1890 the British Association for the Advancement of Science had a committee on standard units and they invented a whole list of new names, a velo, a celo, a bole, a kine, a barad, a dynam.[1] They were given prominence in the papers for a while, but they are now forgotten. The electrical engineers for many years had the weber, but modern text books have dropped it. New units may be suggested, may be reported on by committees, approved by editors, adopted in text books, and used to torture students, but it is hard to get them adopted in practice. Let us hope that the myriawatt will not persist in literature as long as the poundal and ingot iron and the weber did, but rather that it will "die a-bornin'" as did the velo and the celo and the dynam.

THE VIM SYSTEM OF ENERGY UNITS

Besides the paper by Messrs. Stott and O'Neill, there has been another recent attack on the English system of units of power and energy, viz., the attempt of the Bureau of Standards[2] to destroy

[1] See The Engineer (London), July 4, 1890.

[2] Circular No. 34, June 1912. The Relation of the Horsepower to the Kilowatt.

the old definition of a horsepower as 550 ft-lb. per sec., or 33,000 ft-lb. per min., and to define it as 746 watts.

Practically the only excuse for the introduction of these new definitions or units is that there is some little difficulty and liability of error in making the arithmetical computations required to translate horsepower into kilowatts, kilowatts into foot-pounds per second, etc. The difficulty arises from the fact that when the practical electric units, watt, ampere, etc., were originated, no attempt was made to connect them with any units of the English system, but instead they were connected with the C. G. S. system by the relation, 1 watt = 10,000,000 or 10^7 C.G.S. units, the unit of force in that system being the dyne, which has the most inconvenient relation to any practical unit, either of the English or the metric systems, viz., 1 dyne = 1/980.665 gram, the gram (force) being the force that gravity exerts on a gram of matter at a location where $g = 980.665$ centimeters (= 32.1740 feet) per sec.

Even if the mechanical and electrical units were brought into harmony, the fact remains that there is no simple relation between any other energy unit and a heat unit in either the English or the metric system; thus the mean calorie is defined as 4.1834×10^7 ergs.* and the B.t.u. is equivalent to 777.54 ft-lb., and the kilowatt to 3415 B.t.u. per hr.

If there are to be any changes made in our system of units, for the purpose of simplifying arithmetical work and lessening the number of factors of conversion that are needed, it is suggested that an attempt be made to bring both electrical and thermal units into a simple relation with the English system. The writer has discovered a method of doing this and wishes to submit it for discussion. He calls it the "Vim System" (from the Latin, *vis*, force, power, energy).

The vim system has the pound,[1] foot, second and volt as basal units, and two new basal units, the therm = 5/7 kilogram calorie = 9/7 B.t.u., and the vamp = 1.3558 amperes. From these six units are derived the following:

1 vim = 1 ft-lb. per sec. = 1 volt-vamp (direct-current) = 1.3558 watts

1 kilovim = 1000 ft-lb. per sec. = 1 therm

Equivalents of New and Old Units

1 kilovim = 1.3558 kw. = 100/55 h.p.

* Steam Tables and Diagrams, Marks and Davis, p. 92.

[1] Pound force, the force that gravity exerts on a pound of matter at any place where $g = 32.1740$.

1 h.p. = 550 ft-lb. per sec. = 0.55 kilovim = 0.55 therm = 745.7 watts *
1 therm = heat required to raise 1 lb. water 5/7 deg. cent. or 9/7 deg. fahr. = 9/7 mean B.t.u. = 1000 ft-lb. per sec. = 1 kilovim-second
1 unit of evaporation (970.4 mean B.t.u.) = 754.8 therm
1 vim-second = 1 volt-vamp = 1 ft-lb. = 1/1000 therm
1 B.t.u. = 777.54 ft-lb. = 7/9 therm = 0.77778 therm †
1 kw. = 0.73756 kilovim = 737.56 vim = 737.56 ft-lb. per sec. = 1.3410 h.p.
1 ampere = 0.73756 vamp

All that is needed to facilitate the introduction of the two new units, the therm and the vamp, is to make a new graduation on the thermometer scale, so that 1 deg. V = 5/7 deg. cent. or 9/7 deg. fahr. and a new graduation on the ampere-meter, so that 1 vamp = 1.3558 ampere. Since amperes = volts ÷ ohms, a new unit of resistance, the vohm = 0.73756 ohm, will be needed to make vamps = volts ÷ vohms.

If a new thermometer scale is adopted with the value of the degree taken at 10/14 deg. cent. = 9/7 deg. fahr., the question arises where shall the zero be located. The centigrade scale is defective in having its zero at the freezing point of water, making it necessary in so many cases to use minus figures. The fahrenheit zero is scarcely low enough. It would be well to place the zero of the new thermometer below the freezing point of mercury. If we place it at 60 deg. below the freezing point of water, we shall have 200 as the boiling point, and the relation between the new scale and the old ones will be expressed by the following formulae:

$$\text{Deg. V} = 1.4\ C + 60 = 7/9\ (F - 32) + 60$$

The zero of the new scale will be at −42 6/7 deg. cent. and −45 1/7 deg. fahr. The relation of the three scales is shown herewith:

Deg. Cent.	Deg. Fahr.	Deg. Vim	Deg. Cent.	Deg. Fahr.	Deg. Vim
−50	−58	−14	30	86	102
−40	−40	4	40	104	116
−30	−22	18	50	122	130
−20	− 4	32	60	140	144
−10	14	46	70	158	158
0	32	60	80	176	172
10	50	74	90	194	185
20	68	88	100	212	200

The merits of the proposed system are undeniable. Two ques-

* This value, 745.7, is correct if the value of g is taken at 32.1740.

† This relation makes 1 therm = 1000.3 ft-lb. If the equivalent of the B.t.u. is taken as 777.778 ft-lb. then 1 therm = 1000 ft-lb. exactly.

tions arise concerning it: (*a*) Do its demerits, if any, offset its merits? (*b*) Is it possible to have a new thermometric scale and a new ampere (the vamp) introduced into engineering practice, and to have people think in therms, kilovims and vamps?

George H. Barrus. It is hoped that the members of The American Society of Mechanical Engineers will not be induced to adopt the recommendations of the three electrical engineers constituting the Committee on Myriawatt, as reported in the resolutions published in the February Journal of the Society. By examining the preamble of the resolutions it will be seen that these recommendations are based solely upon the paper by Messrs. Stott and O'Neill and as no other justification for the committee's action is given, the paper itself may properly be analyzed with a view to determining the exact merits of the subject.

In the opening paragraph, the term myriawatt is launched upon engineering literature as "a new unit of power." The myriawatt is not a new unit. It is no more a new unit than the watt, and it is not even a unit, because the watt is the real unit, and its characteristic as a unit is in no wise changed simply by multiplying it by 10, 100, 1000, or 10,000. A myriawatt is not a whit more a new unit of power than a kilowatt (and it is not by any means so well adapted for such a unit as the kilowatt) because the prefix "myria" is rarely used and comparatively unknown, while the prefix "kilo" is at the end of almost everyone's tongue who has to deal with weights and measures.

In the same opening paragraph the paper next affirms that the proposed new unit "if adopted will afford a basis of comparison of all converters of energy, thermal or mechanical." What is the matter with the watt or the kilowatt affording just such a basis of comparison without the adoption of anything new? There is no particular virtue in using 10,000 watts as a basis of such measurement instead of 1000 watts, or even 1 watt. The watt is the basis of them all and that basis is available now and has been available heretofore for anyone who cares to employ an electrical unit for the comparison of different forms of energy.

The same paragraph goes on to assert that the proposed unit if adopted will be "international in its character." The watt unit is already international in character just as it has been for years past. Multiplying this unit by 10,000 introduces not one iota of change in its international characteristics.

Continuing the first paragraph, the paper then proclaims that the proposed unit is " merely a new multiple of the watt." What is there new about the figure 10,000? Or, for that matter, what is there new about any known multiple? Why all this juggling of electrical language when the whole matter avowedly simmers down to simply a " multiple of the watt," one of the commonest of electrical standards?

Let us now consider the reasons presented in the paper for adopting the proposed myriawatt basis of boiler capacity:

The first reason advanced is that " laborious calculations " are involved in the conversion of the various power units of different countries to the same basis of comparison. It is quite true that a certain amount of calculation is required to convert a result figured on one basis to that referred to another basis, but to affirm that the calculation is laborious or to give the impression that it involves a number of computations is wholly misleading. There is many an engineer who can make such a calculation in his head and determine the substantial result almost at a glance. It is merely a question of one simple multiplication and one simple division.

Second, in referring to the use of the expression boiler horsepower the authors make the facetious observation that " one has yet to find where the ' horse ' comes in." The term myriawatt, however, is just as foreign to the work of a boiler as the appellation horse. The function of a steam boiler is solely to evaporate water and make steam. It does not fabricate watts any more than it breeds horses, and if it is wrong to express its output in terms of horsepower, it is equally wrong to express it in watt-power or in myriawatts.

As a third reason for the adoption of the myriawatt, the paper refers to the growing use of the term kilowatt which it characterizes as " the one unit of power output." Almost in the same paragraph the authors override this one and only kilowatt unit of power output and substitute the myriawatt, stating as the alleged object " to form a connection between the boiler...... and the generator......" In other words the kilowatt connection between the two, which is already available to those who care to make use of it, is raised tenfold, and then it becomes the one thing needed to bind the two together. Why the connection between a boiler and generator secured by using the multiplier 10 is any different from that secured without such a multiplica-

tion, is not explained, but it may be inferred from the stress which is later placed on the fact that 10,000 watts differs only 2 per cent from a boiler horsepower, that it is deemed advisable to cling as closely as possible to old associations, even to the old "horse," and then give him a kick and throw him over.

The paper states that the proposed myriawatt is designed to apply to the output of a boiler or producer, which corresponds also to the input of all dynamical machinery, and that the term "by its very sound gives a clue to its meaning." The spoken sound of the word "myriawatt" gives not the faintest idea whether the word refers to input or output of a boiler or producer, any more than it does with reference to input or output of the machinery which it supplies. It does not furnish even a clue by sound regarding the number of watts to which it refers such as would appeal to ordinary engineers and laymen. Very few engineers are educated in Greek derivatives, from one of which the term myria is selected. Engineers and laymen are familiar with the word "myriad," which is in common use; but this word ordinarily carries with it no idea of a fixed number like 10,000. Webster's dictionary gives for a first definition of the word myriad "a vast indefinite number," which is a further indication that the mere sound of the word myriawatt furnishes no clue to the meaning of the term, as alleged.

The paper submits an expression for efficiency percentage, based on the use of the proposed myriawatt, which is

$$\frac{\text{10 kw. output}}{\text{myriawatt input}}$$

This is merely another mode of expressing the relation

$$\frac{\text{quantity of output}}{\text{quantity of input}}$$

irrespective of the unit employed in expressing the two quantities. This efficiency fraction referred to myriawatts is readily changed by substitution to read

$$\frac{\text{10 kw. output}}{\text{10 kw. input}}$$

and the latter expression, after cancelling the two figures 10, becomes simply

$$\frac{\text{kw. output}}{\text{kw. input}}$$

Thus it appears that the myriawatt drops out and becomes the

kilowatt, and in so doing it leaves a much simpler fraction, and one unincumbered by an unknown or unrecognized term. This fact is made doubly clear by the following numerical example:

Assume an output, measured at the switchboard, of 1000 kw.; a steam consumption, all-told, of 20 lb. per kw-hr.; a steam pressure of 150 lb.; a feedwater temperature of 100 deg.; and a percentage of moisture in the steam amounting to 1 per cent. Using these data for the computation of efficiency, there are certain preliminary calculations required, the first of which is the determination of the heat units in the steam. The number of heat units per pound of steam corrected for moisture is found by working out the following calculation, the items given being taken from steam tables:

$$(1195 - 68) \times \left[1 - 0.01\left(\frac{1195 - 338}{1195 - 68}\right)\right]$$

The resulting B.t.u. becomes 1118, and the heat units consumed per hour, $1118 \times 20 \times 1000 = 22{,}360{,}000$ B.t.u. From this quantity the myriawatt input is obtained by dividing it by 34,150, or the B.t.u. corresponding to 1 myriawatt. This division gives 654.7 myriawatts. Inserting the required data in the formula, we now have

Efficiency percentage by myriawatt expression =

$$\frac{10 \times 1000}{654.7} = 15.2 \text{ per cent}$$

By the simplified expression above noted we have efficiency by kilowatt basis equals

$$\frac{1000}{6547} = 0.152$$

one of these results being expressed in percentage and the other in a decimal fraction.

The example above given reveals incidentally that the use of the myriawatt for the purpose noted is by no means the easy problem which appears on the face of the formula. To determine the number of myriawatts, there must first be found the heat consumption. There is no short cut for this calculation. All the elements illustrated in the example enter into the determination. Having then found the hourly number of heat units consumed, this quantity must be divided by the number representing 1 myriawatt, viz. 34,150, before the myriawatt input itself is determined.

As a further reason favoring the myriawatt, the paper asserts that its use saves the "tedious operation" involved in finding the heating surface of a boiler plant from the kilowatt output of the engine, when the engine efficiency is known. Instead of involving a tedious operation as alleged, one can apply the boiler horsepower unit and make the calculation in his head. It is only a matter of adding 2 per cent to the result obtained by the proposed myriawatt method; or, to express the exact process, multiplying the kilowatt output by the factor

$$\frac{1020}{\text{per cent efficiency}}$$

instead of the factor

$$\frac{1000}{\text{per cent efficiency}}$$

The minute difference in the element of tediousness involved in these two operations is microscopic indeed.

Coming to the question of applying their myriawatt to the efficiency of steam and gas power plants, the authors meet a veritable Waterloo. It is unequivocally stated that the myriawatt is the term expressing output of steam boiler or gas producer, yet when the power plant is considered as a whole, they set aside this application of the term, and change the myriawatt to mean the input of the boiler or producer as determined from the heat value of the fuel. Thus, strictly speaking, the application of the myriawatt to the plant as a whole makes the efficiency of the boiler or producer 100 per cent—for the input is the output! The absurdity of this situation needs no further comment.

After three times submitting the efficiency formula as applied to various classes of power development which reads

$$\text{percentage of efficiency} = \frac{10 \text{ kw. output}}{\text{myriawatt input}}$$

the authors sum up their conclusions by saying, "Thus, in the term myriawatt lies a simple, logical, and universal means of comparing outputs and inputs of all classes of energy converters." The myriawatt does not furnish a means of such comparison when referred to methods now in vogue, which is either simple, logical, or universal. It is not as simple a means of comparison as the accepted thermal method. Thermal efficiency is given by the expression

$$\frac{2546.7}{\text{B.t.u. per h.p-hr.}}$$

i.e., a constant quantity divided by a single variable, the variable being merely one of the quantities regularly determined on a test. The myriawatt method requires two variables, i.e., one variable quantity divided by another variable quantity, and one of these variables is a new quantity not otherwise computed and requiring an independent calculation.

Neither is the myriawatt method so simple as the use of a kilowatt basis, which has been fully pointed out.

The proposed method is not as logical as those now in vogue. There is nothing logical in adopting a new unit of measure when the existing unit answers the same purpose in a better manner. If the input and output require to be expressed by electrical units, the watt is the only logical unit; or if a multiple of the watt is desired, the logical multiple is the kilowatt which is universally known and perfectly adapted to the purpose, and not a trumped-up multiple which is recognized by no one and which is in no sense specially fitted for such use.

Even the watt, it must be admitted, is not a logical unit for the purpose. There is no characteristic pertaining to electrical work, which makes a watt, or any other electrical unit, a logical representative of the heat produced by the combustion of coal, or representative of the number of pounds of water evaporated in a boiler, or of the weight of steam passing into an engine cylinder or turbine, or of the number of cubic feet of gas or weight of fuel supplied to a gas or oil engine. Neither is there any logical connection between the electrical unit watt, or any other electrical unit, and the power developed on the shaft of a prime mover. Such a unit is absolutely foreign to the principal work required of locomotives, or that of steamship power plants, or of rolling mill engines, of blowing engines, of air compressors, of pumping engines, or of belt-driven manufacturing plants, and the like. It is true that some small part of the heat energy of an electric power plant is converted into electrical energy, and from the viewpoint of the electrical generator in such cases the watt seems on the surface to be the logical unit by which to trace the change of energy from furnace to switchboard. Even this, however, is a very short-sighted view of the matter for the reason that out of the total heat energy of the coal consumed barely one-eighth reaches the bus-bar in the form of watts. The inventors of the proposed myriawatt expression may be thanked for the example given on the closing page of their paper which calls

attention to this telling bit of information. The watt output of the steam power plant referred to in this example is 12 per cent of the input at the furnace. We certainly do not want the tail end of a few power plants to be given such a controlling influence over the vast aggregate of power plants in general. The broad field of mechanical engineering which has to do with measuring the various forms of energy with which it is so widely concerned, finds no place for a unit of comparison that is so narrow in its application as the unit watt.

The only absolutely logical method of expressing the various forms of energy with which power plant apparatus is concerned, is thus shown to be the use of some form of heat measurement. Even the paper itself vouches for the truth of this assertion. The British thermal unit is the only absolute standard which the paper countenances, and, what is more, the underlying principle concealed within the mystical and meaningless flourish of myriawatts in this paper is the advocacy of a heat unit standard of comparison.

These are all the reasons advanced in the paper in favor of the proposed myriawatt basis of measurement, and so far as I can see, not a single one justifies its adoption.

Turning now to the resolutions adopted by the joint committee reported in the February Journal, there is no call for the new term myriawatt as applied to boiler capacity or to any other measure of thermal or mechanical power as referred to in the first resolution, because the familiar term kilowatt is wholly adequate for the purpose, whenever any such electrical quantity is needed.

As regards the recommendation contained in the second resolve that the myriawatt expression of thermal or mechanical power be exclusively used " in connection with boilers, producers, turbines, and engines," it is almost preposterous. There is a familiar saying that it is one thing to lead a horse to water, but it is quite another thing to make the horse drink. Such a recommendation by its very nature is so drastic as to defeat its own object. Where is the mechanical engineer who will adopt the term myriawatt for expressing boiler input or output, engine or turbine power, and exclude the various familiar expressions relating to mechanical energy at the behest of this recommendation? Likewise how many steam users will be content to abandon the familiar term expressing the horsepower of a boiler and sub-

stitute myriawatts, just because a high-tension electric imagination views the boiler as a watt-maker instead of a steam-maker. Mechanical engineers have no use for myriawatts and it is sincerely hoped that the Special Committee of Electrical Engineers who are trying to induce the membership to adopt them in their power calculations will find their efforts have been in vain.

TEST OF A HYDRAULIC BUFFER

By Carl Schwartz

ABSTRACT OF PAPER

The paper discusses the performance of a hydraulic buffer for railroad terminal stations and the means used for the test. The results show the energy absorbed by the buffer under various conditions of train speed and weight and indicate how a buffer should be constructed to be least harmful to the train equipment.

TEST OF A HYDRAULIC BUFFER

By Carl Schwartz, New York

Member of the Society

The object of this paper is to describe the methods used to determine the performance of an experimental hydraulic buffer for railroad terminal stations and the results obtained; also to illustrate the conditions imposed upon equipment when striking the buffer. It is not intended to enter into the question of design of hydraulic buffers nor to discuss the relative advantages and disadvantages of various means to protect the ends of the railroad tracks against overrunning of trains.

2 The office of a buffer being to bring a locomotive or a train to a standstill when, either by accident or carelessness, it overruns its stopping point, an ideal buffer should be constructed so that during the period of its travel the pressure exerted against the train will be uniform. The buffer will thus absorb the greatest amount of work possible with the smallest maximum resistance against the train, and if it fulfils this condition the reaction will be least harmful to the equipment. In how far the buffer installed in its present form approaches ideal conditions will be shown by the records.

3 The buffer tested consists of a cast-steel cylinder of 22 in. internal diameter, or 380 sq. in. area, and 11 ft. working length. The cylinder is grooved to permit a variable quantity of water to pass by the piston, the amount depending upon the position of the piston, and is largest with the piston drawn out in position to receive a train.

4 The piston proper is attached to a steel ram 10 in. in diameter, extending through a stuffing box, and carrying at its extreme end a head of cast steel with a wooden protection board accurately aligned with the locomotive buffer. The buffer cylinder is connected to city water service, the pressure of which is sufficient to drive the

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piston out, and the water discharged during the stroke is disposed of to the sewer.

FIG. 1 FRONT VIEW OF BUFFER

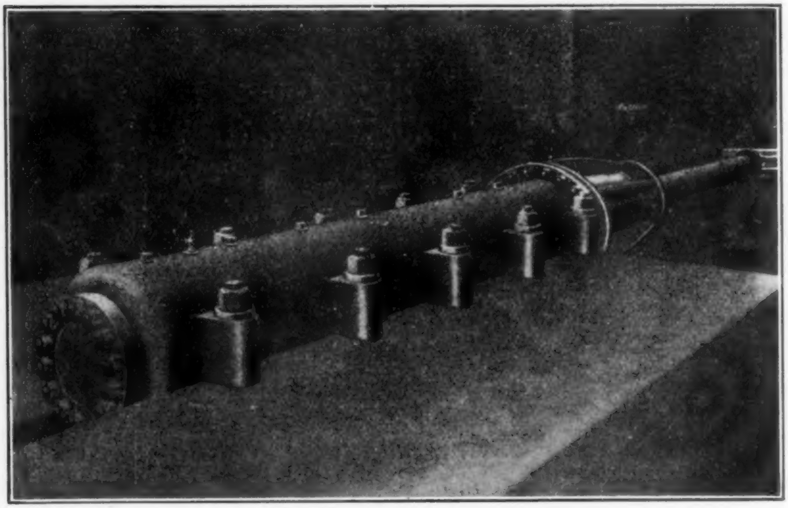

FIG. 2 SIDE VIEW OF BUFFER

5 The buffer is installed rigidly upon and partly imbedded in a block of concrete 20 ft. long, 12 ft. wide and $10\frac{1}{2}$ ft. deep, a total of 90 cubic yards. It is held on each side by five bolts of $2\frac{3}{8}$ in. in diam-

eter extending through the foundation into bed rock by a length varying from 6 ft. in the rear to 13 ft. in the front. The weight of the structure is approximately 390,000 lb. The buffer is illustrated in Figs. 1 and 2.

6 The information required to determine the performance under different working conditions outside of the weight of the train is principally:

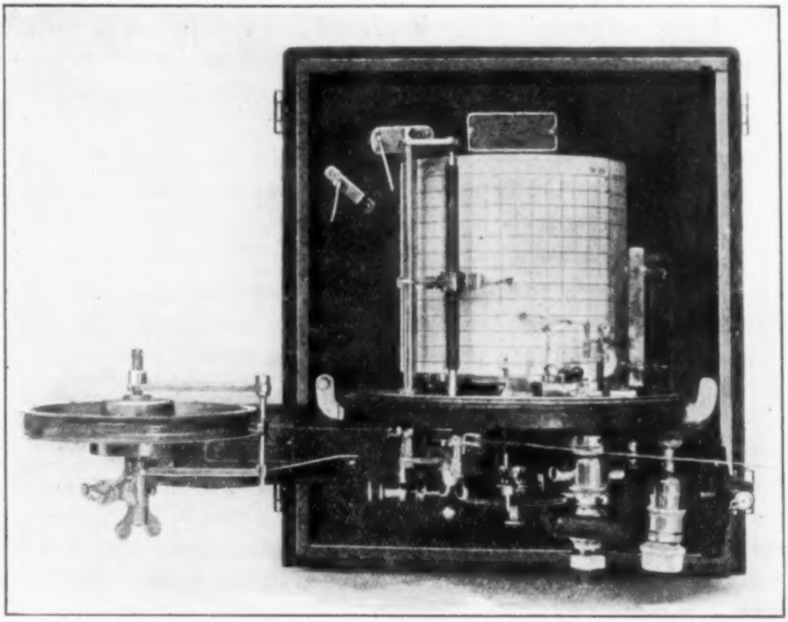

FIG. 3 RECORDING INSTRUMENT

a Speed of train striking

b Pressure performance in cylinder during stroke

c Travel of buffer piston.

7 The time of performance being exceedingly short, it was necessary to record the readings automatically, and a special instrument for this purpose was built by an instrument manufacturer on specifications prepared by the writer. See Fig. 3. This instrument consists of the following parts or mechanisms:

Recording Cylinder. A vertical cylinder bearing a recording chart is driven through a worm gear by a small electric motor and can be adjusted by means of a speed regulator to make one revolution in 12 seconds. The circumfer-

ence of the cylinder being 24 in., 2 in. corresponds to a period of 1 second.

Train-Speed Recorder consists of an electromagnet moving a pen vertically over the chart in five successive steps. Five contacts were placed on the track 25 ft. apart in front of the buffer, and these contacts were made and broken by the train and actuated the speed recorder.

Pressure Recorder is constructed like a steam-engine indicator and by the change of pistons and springs can be used for recording pressures from 0 to 2400 lb. per sq. in. Connection to the rear of the buffer cylinder was made by a small copper tube.

Piston-Travel Recorder consists of a worm screw carrying a pen vertically over the chart and is actuated by a cord running from a wheel on a winding spring over a wheel on the worm screw to the head of the buffer.

8 The pressure recorder and piston-travel recorder, operating above each other simultaneously, give the position of the buffer piston and the hydraulic pressure prevailing at any position of the piston.

9 A few preliminary trials were made to adjust the testing apparatus, ascertain approximately the performance of the buffer, and familiarize the engineers making the tests with the apparatus. The tests finally recorded were made on March 8 and 9, 1913, with the equipment and train speeds as given in Table 1. The travel of the buffer piston and the maximum pressure in the buffer cylinder as recorded are also given.

10 From the readings obtained the curves in Figs. 4, 5, 6, 7 and 8 were plotted. In Fig. 4 the highest speed tested was 8.10 miles per hour, at which the maximum cylinder pressure was found to be 1135 lb. per sq. in., corresponding to a total resistance of 431,000 lb., 18,000 lb. of which was balanced by back pressure, leaving 413,000 lb. effective to stop the train. All readings applying to the light locomotive fall almost exactly on the curve and the curve has been extended to show the probable pressure at higher speeds. The readings applying to trains do not coincide as closely with the curve for the reason that the car couplings and the swinging of the cars back and forth had an erratic influence.

11 In Fig. 5 curves *a*, *b*, *c* and *d* apply to locomotives and trains of 100 tons, 228 tons, 343 tons and 458 tons respectively and show corresponding maximum piston travels of between 3 and 7 ft. It

will be seen that above $5\frac{1}{2}$ and 6 miles per hour the speed of the train has practically no influence upon the travel of the piston; also below $5\frac{1}{2}$ miles per hour the difference in piston travel due to train speed is relatively small.

12 Figs. 4 and 5 illustrate the fact that the impact and pressure against the train depend largely on its speed and that the piston travel is principally a function of the train weight.

TABLE 1 RECORD OF TESTS

Test No.	Equipment	Weight, Tons	Speed Striking, M.P.H.	Piston Travel, Ft.	Max. Cylinder Pressure, Lb. per Sq. In.
4*	Locomotive	100	4.45	2.69	460
5	Locomotive	100	5.00	2.65	525
8	Locomotive	100	5.30	2.70	585
10	Locomotive	100	6.40	2.90	730
1†	Locomotive	100	7.21	3.00	940
2	Locomotive	100	8.10	3.00	1135
3	Locomotive	100	7.12	3.00	940
4	Locomotive	100	7.70	3.00	1030
5	Locomotive, 2 cars	228	4.42	4.25	490
6	Locomotive, 2 cars	228	4.48	4.25	460
7	Locomotive, 2 cars	228	5.37	4.30	690
8	Locomotive, 2 cars	228	6.50	4.50	790
9	Locomotive, 4 cars	343	3.15	5.25	230
10	Locomotive, 4 cars	343	2.90	5.20	200
11	Locomotive, 4 cars	343	4.80	5.75	515
12	Locomotive, 4 cars	343	5.76	5.85	790
13	Locomotive, 6 cars	458	4.50	6.56	460
14	Locomotive, 6 cars	458	5.92	6.50	820

* The first four tests, Nos. 4, 5, 8, 10, were made March 8, 1913.
† Tests 1-14 were made March 9, 1913.

13 The curve in Fig. 6 was derived from the preceding and is intended to determine the maximum capacity of the buffer. The highest train weight tested was 458 tons and the extension of the curve shows that a train weight of 1000 tons will drive the buffer piston probably between 10 and 11 ft., or about the total travel for which the buffer is constructed.

14 Fig. 7 covers test No. 1 on March 9 and the curves show the complete performance with a 100-ton electric locomotive running light, as follows:

a Speed of the locomotive approaching and during the stroke
b Pressure during the stroke
c Horsepower absorbed.

The area covered by the horsepower curve gives the total energy absorbed by the buffer as 368,000 ft-lb., to which should be added

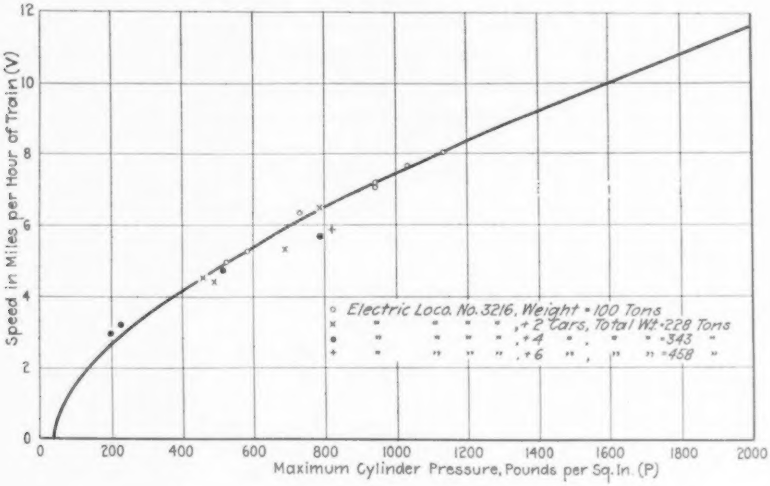

FIG. 4 PRESSURE IN BUFFER AND TRAIN SPEED

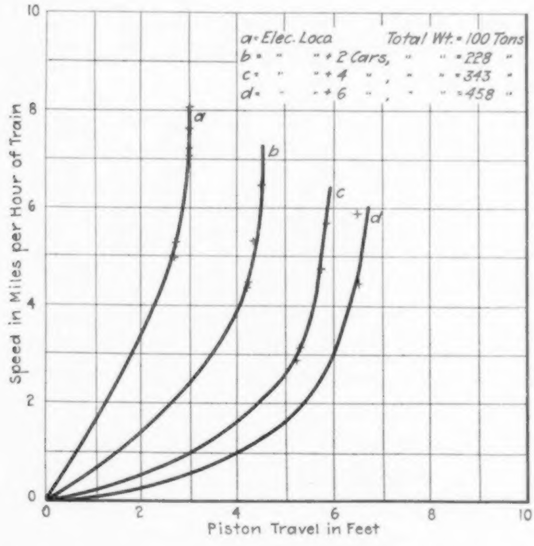

FIG. 5 WEIGHT AND SPEED OF TRAIN AND PISTON TRAVEL OF BUFFER

the resistance of the locomotive, calculated at 2400 ft-lb., to obtain a total resistance of 370,400 ft-lb. The energy in the locomotive

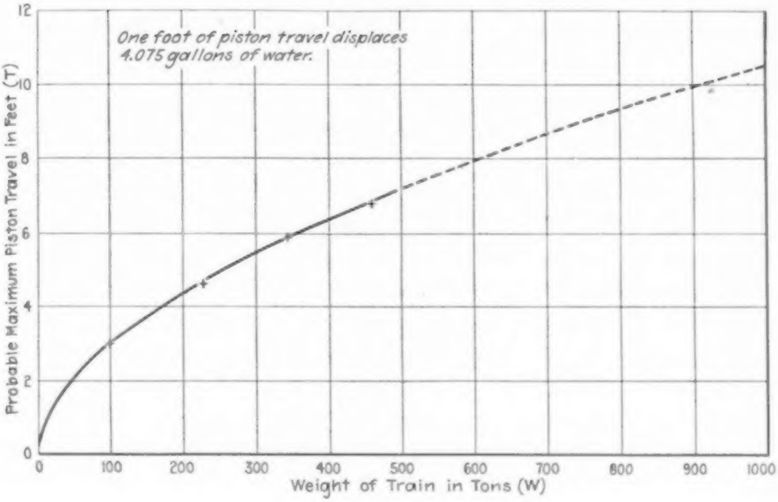

FIG. 6 WEIGHT OF TRAIN AND MAXIMUM PISTON TRAVEL OF BUFFER

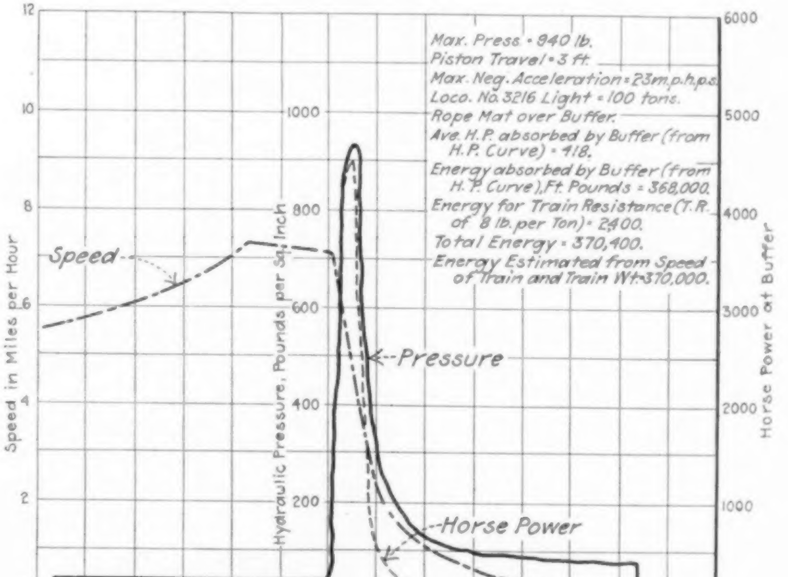

FIG. 7 TOTAL PERFORMANCE—TEST NO. 1, MARCH 9, 1913

based upon speed and train weights has been approximately calculated at 370,000 ft-lb., which coincides closely with the resistance recorded. The pressure curve starts with the city water pressure of about 40 pounds and was found after the stroke to be about 80 pounds, the difference being due to resistance in the discharge valve.

15 Fig. 8 covers test No. 11 and the curves show the complete performance with a train consisting of a 100-ton locomotive and four pullman cars, the total weight of the train being 343 tons. In comparing this curve with Fig. 7, the following should be noted:

16 The maximum pressure is only about 500 lb. instead of 900 lb. because the speed of the train was only 4.8 miles per hour instead of 7.2 miles per hour. The peaks in the pressure curve are probably due to the locomotive and cars striking separately about as follows: Locomotive buffer 300 lb., locomotive body 500 lb., first car 390 lb., second car 300 lb., third car 420 lb. and fourth car 360 lb.; but evidently the train was drawn together and pulled apart, which makes the performance somewhat irregular. Comparison between the energy absorbed by the buffer and the energy in the moving train shows a discrepancy of about 128,000 ft-lb., or roughly, 25 per cent, which can be accounted for as energy absorbed in the train by its parts swinging back and forth during the impact.

17 Other tests were calculated like the results given in Figs. 7 and 8 and show similar and consistent performance.

CONCLUSIONS

18 Referring to Fig. 7, it will be seen that the bulk of the energy is absorbed during the first $\frac{1}{4}$ second of the stroke; the impact was considerable after striking, the pressure falling off immediately after exceeding the maximum. Fig. 8 would show similar results had the speed of the train been higher than 4.8 miles per hour.

19 It was demonstrated during the tests that the buffer was sufficiently effective to prevent damage to the locomotive or equipment though the speeds were at times relatively high.

20 It is evident that the impact can be made smaller by distributing the pressure uniformly over the period of the stroke. To do this the leakage in the buffer should be increased at the beginning of the stroke to reduce the initial peak in the pressure curve at speeds exceeding, say 4 miles per hour. This will increase the travel of the piston for a given train weight and reduce the capacity of the buffer to some extent. If the leakage is brought into definite relation to the pressure curve the buffer should offer a uniform resistance against the train.

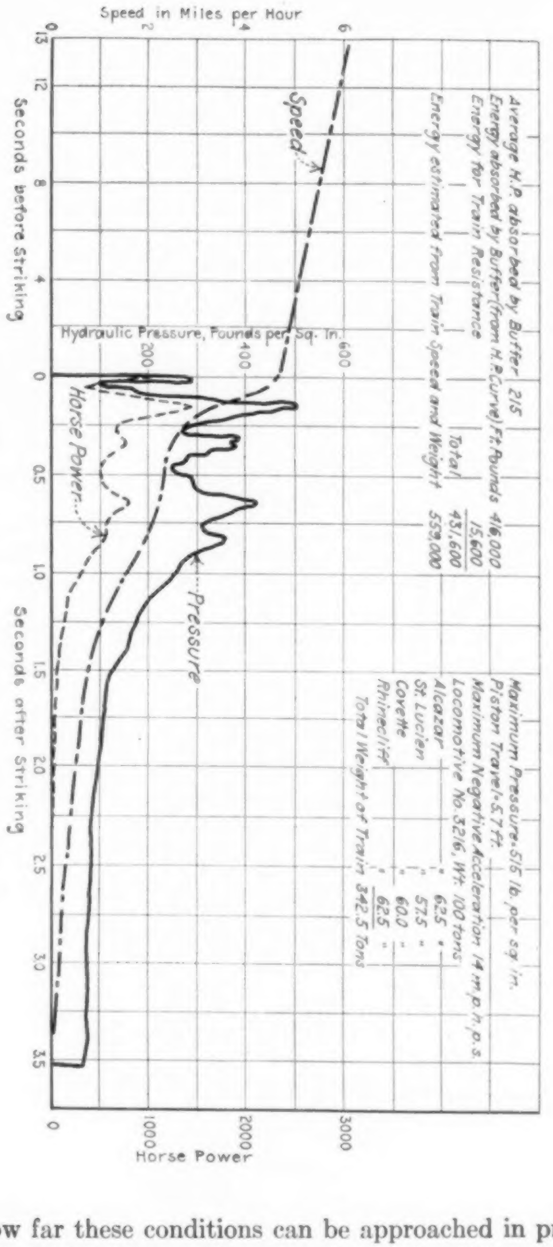

Fig. 8 Total Performance—Test No. 2, March 9, 1913

21 In how far these conditions can be approached in practice is a matter of investigation and the writer hopes that this contribution may be of assistance in understanding the conditions to be fulfilled.

DEBARMENT OF CITY CONFLAGRATIONS

By Albert Blauvelt

ABSTRACT OF PAPER

The intent of this paper is to eliminate through facts and experience in hand those things which cannot debar city conflagrations, and deduce those things which can combine for debarment.

The paper explains the two ways in which conflagrations begin, and reviews various safeguards and methods of fire protection which singly cannot debar conflagrations. Of these the establishment of fire limits, an ample water supply and adequate fire department as already developed cope with all fires except the true conflagration type of hot blast.

Two plans for debarment are discussed: one by deflection by means of the walls of buildings constructed of fire-retardant materials and having wire-glass windows; and the other by absorption by means of sprinklered buildings.

The advantages and disadvantages of each are given in detail, together with a summary of values, costs and gains attending the equipment recommended in the paper.

DEBARMENT OF CITY CONFLAGRATIONS

By Albert Blauvelt, Chicago, Ill.

Member of the Society

Every conflagration must necessarily begin in one of two ways, or with a combination of both, Chicago in 1871 and Baltimore in 1904 being examples of the two types.

2 The Chicago fire started outside of the congested district, developed into hot-blast form, and swept through and beyond the congested district, and burned out for lack of fuel.

3 On the other hand, the Baltimore fire started in the heart of the city and ramified more swiftly than the firemen could operate; then took the hot blast form and burned out for lack of fuel.

4 Such great conflagrations arouse interest in plans (*a*) to debar the present ease of spread of fire inside the costly districts; and (*b*) to debar any deep inroad of fires which may get away from firemen in the outskirts, which admittedly are too spread out and cheap to be adequately protected.

5 The first problem would necessarily be solved by a solution of the second because the latter involves the more severe type of fire, a moving fire with a trail of burning embers making fire department work impossible from the rear. Such a fire has a central hot blast longer than any high pressure or other hose stream and a brisk breeze blowing on the hot blast in a relatively horizontal position compels abandonment of the advancing front.

6 Such a hot blast has never been stopped by firemen while the wind held, but has, however, been checked and deflected upward by barriers consisting of two or more fire walls or their equivalent, with a free air space between, as in the case of various moderate, yet true hot-blast fires which have been stopped by an alley fully shuttered on each side.

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7 It has also been possible to absorb the hot-blast attack of such fires by a very deep and fixed mass of spray in the form of sprinklered buildings. The Boston fire of 1893 was largely absorbed by an exceptionally good water supply in such form, and a somewhat similar experience was had at Toronto in 1904.

8 These successful experiences in checking hot-blast fires by deflecting the flame or by absorbing it in a mass of spray have been but little appreciated and instead of acting upon the lessons which they teach, our cities today have a collection of safeguards, part of which lend themselves to the debarment of conflagrations and part of which do not.

SAFEGUARDS WHICH SINGLY CANNOT DEBAR CONFLAGRATIONS

9 The recognized and partly recognized safeguards against fire, but no one of which alone can debar conflagrations, are twelve in number, viz., fire prevention; the fire limits; the water supply; the fire department; the high-pressure fire system; the uniform hose thread; the water curtain; the so-called fireproof building; the horizontally divided building; the protected window; the sprinklered building; and the piped building.

10 Dynamite, private hose, steam jets, carbonic gas systems, and fire walls separate from buildings are not listed because they are not recognized by fire chiefs for valid reasons.

11 *Fire Prevention.* This subject, in an engineering sense, is limited to reducing the frequency of fires. The preponderance of disasters from trivial, unknown or unguessable causes appears to forbid hope of debarment of conflagration through fire prevention. Besides this, a half century of experience with our cities shows that the skill and effort directed to prevent fires from becoming disasters has been successful within 0.00003 of the total fires. This 0.00003 is what has hurt, and appears to be the only considerable task of correction remaining for the engineer.

12 *The Fire Limits.* This is an expression indicating a central territory at least, within which frame construction or shingle roofs are prohibited and where perhaps certain construction details are enforced, especially for large area buildings. The elimination of frame buildings and shingles is an essential part of any plan to debar conflagration.

13 *The Water Supply.* This paper argues that the water supply is indispensable and also in the main is adequate.

14 *The Fire Department.* While no fire department has ever been able to put water on the front or rear of any hot-blast type of conflagration, nevertheless, the fire departments at time of conflagration have been of gigantic value in keeping the fire from spreading across the wind, in extinguishing brands thrown far ahead, etc. Were this not so, all past conflagrations would have assumed the proportions of that in helpless San Francisco. The fire department, therefore, is indispensable (because also of its signal and salvage aids), and this paper argues to increase its opportunity, but not its cost and size.

15 *The High-Pressure System.* Those cities which are equipped with costly high-pressure systems enjoy an advertisement which does not appear to be shared nor courted by the group of valley cities with reservoirs on high bluffs or hills. The latter afford a high-pressure service for the whole, not parts of such cities and higher pressure and greater volume relative to their buildings than by other means. Powerful high-pressure hydrant systems have also long existed in a goodly number of cities in the form of special inland hydrant lines operated by fire boats.

16 A high-pressure system is a means for saving siamese work, and more easily develops long and large hose streams, but there is nothing about it to enable firemen to use such hose streams either in advance, or in the rear of, a hot-blast conflagration, nor is a high-pressure system especially flexible to check the ramification of fire as at Baltimore in 1904.

17 In general it is a matter of choice between high-pressure hydrants and portable engines. Both plans are good and both plans work much alike as to results.

18 *The Uniform Hose Thread.* Since the fire department is indispensable, ability to double up departments is obviously wise and Mr. Griswold's long labors and separate paper on this subject are exactly in point.

19 *The Water Curtain.* It is fair to say that a water curtain has successfully held off some heavy fires, but never a developed hot-blast conflagration. The fatal weakness of the water curtain is that it is blown away or at least scattered by the brisk breeze which necessarily accompanies a hot-blast conflagration. The depth of the spray is also far too shallow.

20 The water curtain, as shown by fire record results, is a valuable safeguard for moderate exposure fires, or even for fairly

severe exposure when favored by quiet air, but fails in severe tests.

21 *The Fireproof Building.* The typical, so-called "fireproof" building, having merely incombustible floors, roof and walls, cannot debar a conflagration (because of its unprotected windows and large volume of contents) any more than can an ordinary brick building with a good roof.

22 A hot-blast conflagration moves laterally, and a "fireproof" building in its path, as evidenced at Baltimore, is merely a crate which holds up the fuel contents in position for free burning and augments the general hot blast. Such buildings have been somewhat successful with fires in small rooms containing, say 1000 lb. of fuel.

23 It is contents, not buildings, which make the bulk of property loss; contents, not buildings, which are hazardous; contents which burn buildings in most cases, and the low fire cost statistics which purport to compare European engineering with ours include cities which show a low fire cost from sheer poverty of contents.

24 Repeated experience shows that no building can withstand the heat due to burning any large quantity of contents or even very moderate contents if in a large rotunda, half floor office or like large area, constituting in effect a calorific bomb or retort. The writer submits to all who are authorities on heat the feasibility of constructing a structure of bombs or retorts, vented or not, each capable of restraining 10,000 to 50,000 lb. of ignited fuel, at an elevation, and also filling with customary taste and beauty the needs of utility and health for habitation.

25 The fireproof building has unequalled habitability and utility and also lends itself admirably to conversion into a piped building when called for, and even more excellently lends itself to conversion into a building having protected windows.

26 *The Horizontally Divided Building* is designed to hold a fire from rising through the floors. Repeated experience has proven for large area buildings that excessively large and dangerous fires develop quickly if the floors are not fire tight.

27 Such horizontal division is obviously of no value against a hot-blast fire moving laterally from without, and it also does not prevent an internal fire from jumping from floor to floor on the outside of the building.

28 Horizontal fire-tight construction is very rarely found

when fire-tested, its worst drawback being that in the opinion of the public it injures the habitability and utility of the building, hence all sorts of concessions are made.

29 *The Protected Widow.* Protected windows can debar city conflagrations, but do not because there are too few of them, except in a few special and minor localities.

30 *The Piped Building.* The building piped with fusible outlets, whether with automatic water supply or with water promptly applied, can but does not debar city conflagrations for the same reason given respecting the protected window.

MEASURES WHICH CAN DEBAR CONFLAGRATION

31 From the foregoing it appears that the fire limits, the water supply and the fire department are already well developed and do cope with all fires except the true conflagration types of hot blast from without the town proper, or an in-town fire which speedily ramifies through innumerable windows.

32 Against such misfortune we have the successful deflection experiences, and the successful absorption experiences mentioned at the beginning.

DEBARMENT OF CONFLAGRATIONS BY DEFLECTION

33 Taking up the deflection idea first, it is obvious that the walls of existing buildings must be used as deflectors and, as common glass has no fire resisting qualities, the window openings must be closed by shutters, or wired glass in metal sash, or equivalent.

34 Experience shows that when a hot blast reaches a building so prepared as a deflector, failure at first ensues, the heat promptly radiates through the wired glass and ignites the contents of the building, or the shutters leak heat, and the contents inside ignite.

35 Nevertheless, there is a retard effect, and it is obvious that if other buildings located to the right or left of the center of the hot blast have window openings similarly stopped, they must suffer less and the elsewise lateral ramification of the fire decrease.

36 The hot blast is thus largely deflected upward, partly checked and less able to cross the next street or alley, assuming protected windows throughout.

37 Just how many deflector walls and air spaces could be

jumped or burned through by a conflagration of given severity is a matter of judgment based on observation, precisely as the extinguishing power of a hose stream is a matter of judgment from experience, not reducible to exact figures.

38 The writer submits, however, that if all the alley windows were protected and also all the street windows on the second floors and above in the solid three and four-story parts of a town, an outlying district fire, a conflagration could not then bore a hole or a bay into such a district deeper than through four deflector walls and across three air spaces, which would mean two blocks and three streets, or a very wide block with its streets, if divided by an alley.

39 Not that the fire would be put out, nor that tongues and fire brands would not have to be taken care of; but that the hot blast would be deflected upward so the firemen could take a front stand and the general ramification of the fire cease to a state of normal fire department control.

DEBARMENT OF CONFLAGRATIONS BY ABSORPTION

40 There remains but one other known means to regain control of a conflagration, that of absorbing the hot blast by means of the piped building. Experience has demonstrated that a hot blast can be absorbed by a spray if the spray be very deep and fairly housed from the wind as is true of the cage of spray represented by a sprinkler installation in full action in a building whose windows have burned out.

41 The most notable demonstration of this was the Brown-Durell sprinklered building at Boston in 1893. Inasmuch as this building constituted a single large cage of spray which absorbed the main body of a down-town fire that was wholly beyond control, it is certain that a row of such cages of spray, if placed at least two or more deep, would always accomplish the same thing, and do so without the aid of protected windows.

42 The writer submits that if a city throughout all of its three and four-story and higher parts be composed exclusively of suitably piped buildings, and special water supply be provided at the border for at least one block wide, a conflagration from cheap district stuff without could not burn across a street, through a block deep of spray, and across the next street.

43 As before, the fire would not be put out and fire brands would still have to be taken care of; but there would be no rami-

fication of fire in the sprinklered territory and there would be a full restoration of normal fire department control.

VALUES, COSTS, GAINS

44 The Boston big fires proved out burnable property values at a rate of over $500,000,000 per square mile, and it is well known that today there are several city centers which have grown to a far higher rate of concentration of value.

45 To estimate the effect of debarring conflagration from a city district by retaining the fire limits, the fire department and the water supply, and adding thereto by equipping all buildings within such district with protected windows or piped buildings, it seems fair to assume $250,000,000 per square mile as typical of average burnable values over the central districts of our twenty leading cities.

46 For such a square mile, standard automatic sprinkler equipment (including masonry) would cost about four per cent of the burnable values, or $10,000,000 per each square mile with fixed charges of about 16 per cent per year.

47 Plain piped buildings and protected windows would each cost about half as much, or $5,000,000 per square mile for either, and each would have fixed charges (about the same as the buildings), about 9 per cent.

48 The savings which can be computed for such a square mile, with protected windows or with piped buildings throughout, per $100 of burnable values per year, would be:

(*A*)	Elimination of conflagration risk (as per records)	$0.33
(*B*)	Reduction of every-day fire cost due to exposure between individual buildings (tariff rebate)	0.07
(*C*)	Reduction of fire cost occurring within standard equipped sprinklered building (tariff rebate)	0.80
(*D*)	Same as C, but for plain piped buildings (shown later)	0.45

49 Applying the foregoing on a basis of sprinklered buildings alone throughout the square mile, shows investment $10,000,000; fixed charges or loss $1,600,000 or 16 per cent. Gain *A*, $825,000 or 8.25 per cent. Gain *B*, $175,000 or 1.75 per cent. Gain *C*, $2,000,000 or 20 per cent. Net gain of $1,400,000 or 14 per cent.

50 Similarly and solely for protected windows shows investment of $5,000,000 fixed charges, or loss $450,000, or 9 per cent. Gain *A*, $825,000 or 16.5 per cent. Gain *B*, $175,000 or 3.5 per

cent. Gain C or D nominal. Net gain of \$550,000 or 11 per cent.

51 Similarly and solely for plain piped buildings shows investment of \$5,000,000, fixed charges or loss \$450,000 or 9 per cent. Gain A, \$825,000 or 16.5 per cent. Gain B, \$175,000 or 3.5 per cent. Gain D, \$1,125,000 or 22.5 per cent. Net gain \$1,675,000 or 33.5 per cent.

52 In surveying any actual square mile it would develop that but one of the three, viz., protected windows, automatic pipes, or plain pipes, would best suit any one building, and this would be likely to result in a detail plan calling for gross investment of about three per cent of the burnable values at a net gain of about 18 per cent.

53 But figures cannot include the grief, loss of work and trade following every large conflagration.

RESUMÉ OF ADVANTAGES AND DISADVANTAGES

54 Thus far this paper has attempted to show that our fire limits, fire departments and waterworks are today well developed, and that protected windows or piped buildings throughout the costlier districts are all that is needed, in order to debar conflagrations.

55 The fire limits, the fire department and the waterworks are too well known to need further comment. To recapitulate the advantages and disadvantages of the protected window and the two types of piped buildings:

56 The protected window delays the entry of severe fires and also prevents general ramification of fire through innumerable window openings.

57 Not that the protected window does this perfectly, because shutters may be out of order or not get-at-able to close if open, and because wired glass transmits heat by radiation very rapidly. Nevertheless, as aided by existing air spaces, alleys and streets, the protected window is a proven success in practice, whenever its application is general.

58 The protected window is beginning to be required in building codes; it also is tangible to the public eye, something that can be seen as representing a fire stop or check; it has a simple technical structure and therefore is much in the nature of a market staple.

59 When in wired glass form it has some working advantages, at least for skylights, and finds favor with architects on

the better class of buildings. When in the form of shutters, the fire-stop effect is better than for wired glass, but this is largely offset by the fact that shutters do not get the care which comes to a window which is in more or less constant use.

60 The advantage of the piped building with automatic double-source water supply, the well known sprinklered building, is first of all the protection to life that is afforded. Apparently this specific form of fire protection is the only one which to any dependable degree conserves life. An experience with say 10,000 buildings over a period of about 15 years gives rise to the statement that no life has ever been lost in a building so equipped, either by fire or smoke, and to the best of the writer's knowledge this is literally true.

61 While it is true that fires occurring under sprinklers are by no means invariably put out without issue of smoke, the fact is that the operation of an automatic sprinkler system develops a powerful drenching spray not only on the fire but around it, and compels escaping smoke to pass through a dense spray; and the presumption is that the spray takes up the acrid quality and heavier carbon contents of the smoke, and thus has much to do with the proven fact of protection to life.

62 While mathematical safety against loss of life by fire is probably impossible, it is within the truth to say that where people are in masses, or are asleep, safety cannot exist if the main hazards are not under the automatic sprinkler.

63 A second advantage of the automatic sprinkler system, and the one most in point under the title of this paper, is that it has been found in practice that, given brick buildings, well secured pipes, and reasonable water supply, a fire even when of conflagration magnitude cannot burn completely through such spray further than the depth of one, or say two, buildings, thereby debarring far spread of fire from without into such a district.

64 A third advantage of this type of piped building is that the fires are put out so quickly and with such economy of water by reason of its accurate application, and with so little smoke and so great a reduction of the harmful quality of the smoke that the aggregate fire, water, and smoke damage to goods is far less than for any other form of protection.

65 The main advantage of the plain piped building, or building equipped with automatic sprinklers on empty piping with exterior hose coupling for fire department use and relying solely

on the fire department for water supply, is that the first cost and fixed charges make it applicable to the medium value buildings.

66 Another advantage is that of safety to life, compared with that of buildings not piped at all, because in practice the piping and sprinklers can be operated nearly as quickly, and necessarily to the same effect as do automatic water-supplied sprinklers.

67 Still another advantage is that the technique and upkeep essential to efficiency are far less than with the full standard automatic sprinkler equipment.

68 The main disadvantage of the protected window is that it is non-commercial in the every-day sense, inasmuch as it protects only between neighboring buildings and this saving averages too small to cover its fixed charges through cheaper insurance, particularly as it saves but little on the cost of fires originating within the building itself.

69 A disadvantage of the first form of piped building (with standard automatic sprinkler system) is that it is a special engineering product, technical to a high degree, yet depending on this quality for its efficiency, an efficiency seemingly possible to maintain, yet so far only by a few skilled contractors and experts. The system therefore is open to criticism by all who rail at any control of skill or service.

70 Another objection to this form of piped building as it now is applied in the field is that its water supplies are very liberally taken in the form of large pipes direct from city mains through the influence of large property owners, thereby saving them expense of providing private water supply. For Manhattan Island and for Chicago this is not serious because in these two locations city water is of too low a pressure to be generally available for such supply. But in some of our cities there are too few sprinklered buildings to check a conflagration and just about enough of them to jeopardize complete crippling of waterworks and fire department at a time of conflagration by reason of these buildings being wrecked in detail and bleeding the general water supply through the breaking of large pipes.

71 Hence another disadvantage, or at least a special requirement for a piped district, would be that the border of such district would require to be provided with water supply in a manner not to jeopardize the general hydrant system of the city; and this in turn would necessitate a special border pipe line into which water would be pumped or admitted under control.

72 Still another disadvantage of standard automatic sprinkler equipment is that it is expensive in first cost and in fixed charges. The investment and fixed charges do not have any fairly constant relation to the value of each individual building plus contents, and also at city labor costs are usually excessive, except for the fewer large and fairly high buildings.

73 A disadvantage of the plain or empty pipe sprinkler system is that this mode of protection has as yet but few applications; no extended study has been given the art of cheap extinguishment of fire in medium value property. Another disadvantage is that fire department practice is at variance; some chiefs favor and ask for such equipment, and others evade or object to any change or extension of present methods.

74 It does not seem to be generally realized that a building in a down-town district does not burn badly before the department arrives. Were this not so, any modern fire department would not, as the records show year after year, hold the fires within moderate loss, except 0.003 to 0.005 of the total. It is a fact that the fire department does arrive (except in the suburbs) while the fires are yet incipient, though perhaps inaccessible. It seems to be accepted as a matter of course that a costly proportion of buildings shall burn and soak, subsequent to the arrival of the department, for the sole reason that the department cannot quickly put ample water where, and only where, it is needed. Yet to do the latter is all that the standard automatic sprinkler equipment does or professes to do, and as much if not more water can be supplied to empty pipes nearly as quickly by firemen as by a private tank.

75 Even in a case of purposely delayed alarm and sprinklers shut off (incendiary), the writer has seen work done in this manner by only one steamer with wonderful success, extinguishing a four-story fire which otherwise would have required many hose streams, and this after there was no time to lay so much hose, much less set up ladders and crews.

76 The fire cost of plain piped buildings would admittedly be greater than for a standard sprinkler equipment because while there would be no failures through tanks down or pipes frozen or valves shut off, the fire department would not put water on the fires at quite as early a stage of incipiency.

77 A willing fire department, however, would put water on the fire through such pipes while a fire was yet incipient, because

our fire department records show that the vast majority of downtown fires are not put out while incipient by quick work with light appliances.

78 To pay for the larger surface fires and the greater number of sprinkler heads or fusible outlets which would therefore open and make water damage in practice with plain pipes as compared with standard automatic sprinkler equipment, the figures given earlier allow for the typical square mile, $875,000 per year, which would seem excessive, to say nothing of a further offset of $1,150,000 reduction of annual fixed charges.

79 However, the standard automatic sprinkler system has been fully demonstrated for over 20 years and also about 20 years ago was a little better from an economical point of view, fixed charges considered, than it is today, yet it is but just coming into its own. All of this goes to show that the plain piped building must in turn wait for recognition and extend in application by degrees.

ALLOWABLE HEIGHTS AND AREAS FOR FACTORY BUILDINGS

By Ira H. Woolson

ABSTRACT OF PAPER

Factory buildings of excessive heights or areas have long been recognized by underwriting organizations as a grave danger to life and property, owing to the difficulty of controlling fires in them. The men best fitted to determine safe limits of heights and areas are fire marshals and fire chiefs, and accordingly the writer communicated with all such in the United States representing cities of over 20,000 population. Replies were received from 117 representative cities; these have been summarized and form the basis of the paper.

ALLOWABLE HEIGHTS AND AREAS FOR FACTORY BUILDINGS

By Ira H. Woolson, New York

Member of the Society

In the design of factory buildings, one of the vital features tending to control the spread of fire is a judicious limitation of height and area. It is self-evident that whatever restricts a fire reduces the life hazard. Owing to the supreme importance of these two subjects, a person contemplating the erection of a building of this class should give careful consideration to the history of fires in such buildings, and the experience gained in fighting them. The question is more acute in this class of buildings than in any other because of the fire hazard which exists in them, and the economic advantages due to reduced costs in construction and supervision, when several large areas are housed under a single roof. Just where to draw the line so as to produce reasonable safety without prejudice to building investments is the problem.

2 Factory buildings of excessive heights or areas have long been recognized by underwriting organizations as a grave danger to life and property, owing to the difficulty of controlling fires in them. They have for years urged limitations which have been freely ignored by ambitious architects and factory owners, because the suggested restrictions were considered unreasonably drastic. The evidence produced in this paper strongly supports the limitations which were advocated.

3 It is logical to assume that the men best fitted to determine safe limits of heights and areas are the men who have made a life work of combatting fires under all conditions of weather and hazard. With this idea in mind, the writer communicated with all the fire marshals and fire chiefs in the United States representing cities of over 20,000 population. A set of eight questions and a letter of explanation were sent to each. Fire chiefs as a class

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

are not good technical correspondents, therefore it was not surprising that only one-third of the men addressed responded to the appeal. However, replies were received from 117 representative cities well distributed as to size and geographical location. These have been summarized and form the basis of this paper. A few of the replies indicated a misunderstanding of the questions, and these were discarded. The questions were as follows:

1 What should be the greatest height allowed for manufacturing or warehouse buildings *without sprinkler equipment?*

Brick and joist construction..............Height in ft.—or No. of Stories—
Fireproof construction..................Height in ft.—or No. of Stories—

2 Take the same question as No. 1, but assume the buildings to be fully equipped *with automatic sprinklers.* What height would you approve?

Brick and joist construction..............Height in ft.—or No. of Stories—
Fireproof construction..................Height in ft.—or No. of Stories—

3 What should be the greatest floor area allowed in the same class of buildings *without sprinkler equipment?*

Brick and joist construction.......Area in sq. ft.—or Width—ft. Length—ft.
Fireproof construction...........Area in sq. ft.—or Width—ft. Length—ft.

4 If the same buildings were fully equipped *with automatic sprinklers* what area would you approve?

Brick and joist construction.......Area in sq. ft.—or Width—ft. Length—ft.
Fireproof construction...........Area in sq. ft.—or Width—ft. Length—ft.

4 Each building was assumed as a good one of its class, with enclosed stairways and elevator shafts; and the chiefs were requested to base their answers upon experience in fighting fires in the class of buildings described, and to assume restrictions

TABLE 1 GENERAL AVERAGE OF 99 TO 111 REPLIES RECEIVED FROM ALL CLASSES OF CITIES [1]

Type of Building	Stories in Height	Area between Fire Walls in Sq. Ft.
Non-Fireproof, not Sprinklered	3.1	6,300
Fireproof, not Sprinklered	4.9	12,300
Non-Fireproof, Sprinklered	4.6	12,800
Fireproof, Sprinklered	7.0	27,100

Average story height was 12 to 13 ft.

which would afford a reasonable chance of controlling a fire on any floor.

5 Naturally, and quite properly, the replies reflect the local conditions, such as the efficiency of the fire department, the water pressure, the combustibility of the goods being manufactured,

[1] The variation in the number of replies (averaged) resulted from some incomplete answers.

the number of sprinkler equipments in service, and the degree of congestion among the buildings. However, all conditions were represented, and the summary of so large a number of opinions should indicate fairly well the average condition throughout the country. (See Table 1.)

6 The answers regarding allowable heights were much more uniform than those relative to area. It is significant that 83 per cent of the replies would limit the height of a fireproof sprinklered factory building to less than ten stories. The opinions in reference to height of the other classes of buildings were exceedingly uniform, and consistently low.

7 Replies as to permissible areas in sprinklered buildings were widely divergent, but for the unsprinklered classes they were more uniform than would naturally be expected considering the great diversity of conditions under which they were prepared.

8 It is evident from the figures given, that the fire chiefs have no settled policy among themselves as to the credit that should be given to an automatic sprinkler equipment as a fire extinguishing device. A few enthusiasts would permit unlimited area in a sprinklered building, while on the other hand a considerable number would give very little or no increase, when sprinklers are installed. Two chiefs stated that their unfortunate experiences with sprinklers had caused them to lose faith in their reliability. As a whole, however, they are strongly in favor of sprinklers and are inclined to permit over generous areas in buildings so equipped.

9 In order that the replies may be intelligently interpreted they have been separated into three groups, Tables 2, 3, 4, according to size of the city represented, and each group has been analyzed to show the character of the answers given to each question.

10 In the cases referred to by an asterisk, where no limits to areas were given, they were not included in the averages, but were counted in the columns giving the number of answers above the average. In each group it will be noted that about the same number of men gave high answers to all questions, the proportion being one-quarter to one-half of the number in the group. The uniformity of height limits, and the lack of it in the area limits, is very apparent in all groups. It will be noted that the largest area values are given in Groups I and II, comprising the smaller cities. This is significant, and needs explanation.

TABLE 2. GROUP I SUMMARY OF ANSWERS FROM 52 CITIES WITH A POPULATION OF 20,000 TO 50,000

Type of Building	Stories in Height			Answers above Average	Area in Square Feet			Answers above Average
	Average	Max.	Min.		Average	Max.	Min.	
Non-Fireproof, not Sprinklered	2.8	6	1	13	6,000	20,000	1,150	15
Fireproof, not Sprinklered	4.4	10	2	24	12,600	60,000	1,150	15
Non-Fireproof, Sprinklered	4.1	8	2	17	12,300	*60,000	3,000	17
Fireproof, Sprinklered	6.3	12	3	18	27,300	*180,000	5,000	20

* Four votes received in favor of "no limit to area" in this class.

TABLE 3. GROUP II SUMMARY OF ANSWERS FROM 23 CITIES WITH A POPULATION OF 50,000 TO 100,000

Type of Building	Stories in Height			Answers above Average	Area in Square Feet			Answers above Average
	Average	Max.	Min.		Average	Max.	Min.	
Non-Fireproof, not Sprinklered	3.2	6	1	8	8,300	40,000	2,500	5
Fireproof, not Sprinklered	5.2	10	1	6	14,800	60,000	2,400	4
Non-Fireproof, Sprinklered	4.8	10	3	5	16,300	75,000	1,500	5
Fireproof, Sprinklered	7.7	20	4	5	36,300	200,000	4,000	5

TABLE 4. GROUP III SUMMARY OF ANSWERS FROM 36 CITIES WITH A POPULATION OF 100,000 AND OVER

Type of Building	Stories in Height			Answers above Average	Area in Square Feet			Answers above Average
	Average	Max.	Min.		Average	Max.	Min.	
Non-Fireproof, not Sprinklered	3.5	7	1	17	5,400	10,000	900	15
Fireproof, not Sprinklered	5.3	9	2	18	9,800	22,500	2,400	10
Non-Fireproof, Sprinklered	5.0	10	3	15	11,300	22,500	900	13
Fireproof, Sprinklered	7.5	12	4	16	19,400	*80,000	2,500	9

* Two votes received in favor of "no limit to area" in this class.

11 Occasionally the fire chief of a small city has experience which would abundantly qualify him to estimate properly the merits of fireproof construction and sprinkler equipments; more often, however, his city has meager protection of this kind, and consequently he has little opportunity to judge of their efficiency, and it is not strange that he should be a bit extravagant in the credit he would give them.

12 The most rigid restrictions on area are found in Group III embracing the large cities. As fireproof construction and sprinkler equipments are common in most of our large cities, it is reasonable to assume that the fire chiefs of such cities would have had much more experience with such methods of protection, and be better able to decide what increase should be given in the size of a building when such protection is provided, than their less experienced fellow officers in smaller towns. It is thought quite proper to assume that their figures are more nearly correct and should be given the most weight.

13 Significant evidence in support of this argument is found in the fact that four chiefs who give no limit to areas in non-fireproof and fireproof sprinklered buildings are located in cities having a population of less than 50,000 in which there are few fireproof factory buildings or sprinkler equipments. On the other hand only two chiefs, in cities over 100,000 population, suggest a "no limit area" in a fireproof sprinklered building, and none approves such areas for non-fireproof buildings.

14 With these thoughts in view, Table 1 has been changed somewhat to be more in accord with the weight of evidence. It is believed, therefore, that Table 5 represents more correctly the consensus of opinion among the fire chiefs of the country best qualified to judge as to what should be the proper limits of height and area for factory buildings.

TABLE 5 ALLOWABLE HEIGHTS AND AREAS IN FACTORY BUILDINGS

Type of Building	Stories in Height	Area between Fire Walls in Sq. Ft.
Brick and Joist Construction, not Sprinklered.	3	6,000
Fireproof Construction, not Sprinklered......	5	10,000
Brick and Joist Construction, Sprinklered....	5	13,000
Fireproof Construction, Sprinklered..........	7	20,000

15 These values might be increased somewhat under the influence of especially favorable local conditions, as previously explained, but the writer submits that as they represent the average

deliberate judgment of such a large body of men, so well qualified to estimate the hazard which the values involve, they should be given careful consideration, and should be increased only with the utmost caution.

EXTRACTS FROM FIRE CHIEFS' LETTERS

16 The following extracts from letters received from different fire chiefs in connection with this investigation may be of interest as indicating their attitude of mind in relation to the questions asked:

"In my opinion, from a fire-fighting standpoint, *no building* should be built over eight stories."

"In our city there is room to grow on the ground without building high in the air. It is almost impossible for a public fire department to fight a fire from the outside above 75 ft."

"The figures given mean that every 66 ft. by 66 ft. should have a brick wall through length of building with Underwriters' doors; same to be double. As for width, in no case over 66 ft. wide; with solid wall, same to reach above roof at least 6 ft. *Build on ground not in air.*"

"A building 8 or 10 stories high, out in the open where it can be attacked from all sides should be handled very readily by a modern equipped fire department."

"I think that a factory should never be more than four stories high. I almost feel that there is no such thing as fireproof construction from my own experience. I know that it is possible to store enough material in any building to burn it. I am very much in favor of dividing rooms in factories with fire-resisting walls, provided with automatic fire doors."

"While fireproof construction is the best, it is the contents placed therein that is the hazard to life and property. Buildings should not be constructed to a greater height than can be reached by fire department ladders; 85 ft. to upper windows."

"In my opinion no warehouse building ought to be over one story in height. In regard to manufacturing buildings, I will say that I do not approve of any of these buildings being over three stories in height. If they want room, let them build in length and not so high; that is just what makes such bad fires. These buildings have all kinds of combustible material in them and they are sure to jump to another building if they are four or five stories in height."

"It is my opinion that all buildings for manufacturing and warehouses should be sprinklered, and not built higher than what the water supply will furnish and cover."

"Do not think any fire department can successfully fight a large fire over six stories high, and ten stories allowed only when there are two sources of water supply with good pressure."

"Area of sprinklered and unsprinklered buildings should be about the same, on account of increase in height allowed for fireproof buildings."

"All buildings of character named should be sprinklered."

"Joisted brick construction should not be allowed without sprinklers."

"I think a good sprinkler system is one of the best fire preventions that has

been invented in a great many years, and if kept up properly, it is pretty hard for fires to get away."

"If I had my way I would not allow any manufacturing plant to do business until it were properly sprinklered. It does things when they should be done."

"My experience with the 28 factories in this city has been that the sprinkler systems are out of order much of the time. Not looked after properly."

"This department has had no unfortunate experience with the sprinkler system, but, I do not feel inclined to depend upon them."

"The reason for not showing more favor to sprinklered risks, is because our experience with sprinkler systems in this city has shown them to be unsatisfactory, and not to be depended on."

"Stairs should be of steel without any wood sides; if any wood in the construction then there should be sprinklers. Should be sprinklers in all elevators even if they are enclosed, for an elevator is a bad air shaft. Brick factories cut up with wooden partitions are generally hard fires to fight."

"I do not approve of small rooms in factories, they make it very hard for a fireman to fight his way through smoke trying to find a fire when a building of this kind is partitioned off so much."

"In considering the limiting of height and area of a building, the question of accessibility should play an important part."

STEEL PASSENGER CAR DESIGN

In the May issue of The Journal was published a collection of 13 papers upon the subject of Steel Passenger Car Design, given at the New York meeting of the Society on April 8. The discussion which followed the presentation of these papers at the meeting is published herewith.

DISCUSSION

GEORGE GIBBS. On this occasion when the subject of steel passenger car design is under discussion, it may be of interest to make a brief reference to the early history of this important innovation in railway operation which had its origin in connection with the provision of car equipment for the first rapid transit subway in the City of New York. The writer was at that time consulting engineer of the subway construction company in charge of car design and construction. It was obvious that the exacting requirements of the contemplated service, which involved tunnel operation at a high schedule speed with closely spaced trains crowded with passengers, must be conducted with all possible precaution against accident and, further, in a way such as to minimize the fatal consequences of any accident which might occur in spite of such precautions. The two consequences most to be feared from an accident are the breaking up of the cars in the train and the setting of a fire in the wreckage; on an open railway line the consequences of these are serious enough, but in a subway or tunnel they are potentially much worse, because of the confined space which prevents the prompt escape of passengers from the wreckage.

Cars for such service, therefore, should be protected in an unusual degree against the possibility of telescoping in an accident, and the electric apparatus should be installed in a way such as absolutely to prevent the setting of fires. Incombustible metal cars were naturally suggested as the solution of the problem, but

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in the latter part of 1901, when the question of car design was taken up for the subway, it seemed impracticable to consider the adoption of an all-steel car for the large amount of equipment required, because of the fact that no practical steel passenger cars had ever been constructed and it was evident that to develop a serviceable type a number of very serious mechanical problems had to be attacked by thorough study and experimentation. Not least among the problems was that of keeping the weight of a metal car within reasonable bounds, without sacrificing its strength and serviceability; light weight being an essential requirement in rapid transit operation.

As the best practical solution of the car question, it was, therefore, decided to provide wooden cars initially, but to make them of an advanced type with metal underframes, protected floors and copper-sheathed sides, and to mount the electric apparatus in incombustible envelopes. These cars were rightly considered at the time a great advance upon previous practice in safeguarding against accidental fires. The first lot of 500 of these protected wooden type subway cars was ordered in December 1902.

While it was necessary to insure the operation of the subway at the date set for its opening by providing the initial car equipment, the writer believed the steel car feasible, and in this view he was encouraged by George Westinghouse, under whose stimulating advice he was led to persevere in efforts to develop a metal car at the earliest possible date. A. J. Cassatt, president of the Pennsylvania Railroad, was also impressed with the necessity for noncombustible cars in tunnel service, as the great project of the Pennsylvania road in building a tunnel entrance into New York City was then in progress. He accordingly offered to the subway company the facilities of the Altoona shops to build, in the quickest possible time, a sample steel car, the design of which the writer had completed in October 1902. August Belmont, president of the Rapid Transit Subway Construction Company, concurred in this arrangement and early in 1903 the Altoona shops started upon the construction of this car, which was completed in December of that year. Realizing the many difficulties which would be encountered in getting material promptly at that time, commercial shapes were quite generally used in the design, and the car as built was found, therefore, to be quite heavy and not altogether sightly in appearance.

The company still needed 300 cars to complete the early re-

quirements of the subway operation and it became a question of immediate necessity to determine whether these cars should be of wood or be of the all-steel construction. The writer was able, from experience with the sample car, to develop a new design and at a meeting of the executive committee of the subway construction company early in 1904, he definitely recommended the letting of contract for 200 of the new design of steel cars. On the strong endorsement of E. P. Bryan, general manager of the road, Mr. Belmont decided to venture upon this important innovation in railroad operation. The contract for the 200 steel cars was accordingly let in March 1904, and followed October of the same year by 100 more. Both these contracts were taken by the American Car & Foundry Company, which had the courage of its convictions in assuming the heavy responsibility of turning out these large orders at specified time and at a price which was not out of line with that of the previous wooden cars. A number of these cars were received in time for the opening of the subway, October 27, 1904, and are running today.

During the same year the writer, who also had charge of the electrification of the Long Island Railroad, placed an order for 122 steel electric motor cars of practically the same design as the subway cars; this service started June 28, 1905. The Long Island was the first steam railroad in the country to adopt steel cars for its passenger service.

The New York Central a year later placed an order for 125 steel cars and inaugurated their electric service from the Grand Central Station in January 1907.

The Pennsylvania Railroad, as result of the progressive action of Mr. Cassatt, endorsed by Samuel Rea, then vice-president of the company, adopted steel passenger cars for all trains coming into the new terminal, a decision which has since had a far-reaching effect upon the standards of all railways of the country. The question of the best design for through passenger train cars was taken up exhaustively and systematically by this company and was made the subject of a report by a special committee of its operating officials in May 1909. Today this company has in service 2139 steel passenger cars, excluding a large number of sleeping and parlor cars of the Pullman Company, and builds no other type.

William F. Kiesel, Jr. The method of suspension described by Mr. Summers may be very good on short cars, but with long

cars, especially passenger cars, it does not seem sufficiently flexible in the trucks to avoid unbalancing and putting the cars out of shape. The bodies are long and the cars have some flexibility, but in some cases the tracks are such that it is necessary to have excessive provisions for flexibility aside from that in the truck.

John A. Pilcher. Referring to Par. 2 of Mr. Summers' paper on Suspension of Steel Cars, the question of the amount of wind that has to be taken up between the two trucks on the car seems to be exaggerated; in approaching a curve the rise in elevation of the outer rail is about 1 in. in 50 ft. On the ordinary modern passenger car truck centers are about 50 ft. apart so that the total amount of wind is about 1 in. measured at the rails. Considering the car weighs 130,000 lb., with trucks approximately 20,000 lb. each, and the car body about 90,000 lb., in order to take care of the wind in the track, the springs on the diagonals of the car would have to compress ½ in. more than the springs on the opposite diagonal assuming the springs as over the rails. On this same car this would mean that two diagonals would have 20,150 lb., and the opposite two 24,850 lb., or a difference of 4700 lb. This difference in deflection is taken from actual springs.

To analyze this in connection with the swinging hangers, assume these hangers to be 11 in. long, and to be located at an angle with a vertical of 28 deg. 8 min., which is about that shown in the cut, and also assume that they are located approximately over the track (the movement would have to be decreased or increased in proportion to their distance from the rail inside or outside) with a load of 22,500 lb. for each group of hangers.

In order to take care of the same amount of wind in the track as considered in connection with the springs, that is, ½ in. difference in elevation on the opposite sides of the track, the angle would be decreased to 25 deg. 35 min. on one side, and increased to approximately 30 deg. 45 min. on the opposite side in order to bring about stable equilibrium. The vertical loads would amount to 24,935 lb. on one side, and 20,065 lb. on the opposite side, or a difference of 4870 lb., just a little more than when the springs were used. In calculating the deflection of the springs only the deflection of the bolster springs was taken into consideration; the equalizer springs would also have to take an additional load, and would help to reduce the difference of loads necessary to bring about the proper amount of deflection.

Looking at a car from the rear approaching a curve, when the front truck enters the curve the centrifugal force at that point would tend to throw the car body, relative to the truck, actually in the opposite direction from what it should move in order to equalize the stresses. This would put additional torque in the body of the car, which would not be present in the case when springs only take care of this movement. The torque would be rather reduced at the time of entering the curve when the springs only are used.

When both trucks are on the curve all of the wind is out of the car; the centrifugal force in that case throws the car body toward the outside, and would tend to augment the lift in the track on the outside, which is hardly desirable.

Angular hangers, while they may not have been intended for the purpose described, have been in use for a number of years. It is very questionable whether they are of any advantage.

S. A. Bullock. Mr. Pilcher referred to frictionless center plates and adjustable side bearings to reduce to a minimum the oscillation of the car. My experience has been that, to prevent the nosing of a car, which takes place almost entirely upon a tangent, it is necessary to transfer the entire weight from the center plate to the side bearings. Cars of the Pennsylvania Railroad design have been running in the Hudson & Manhattan Subway, and, although they have very short centers, it was found necessary, in order to prevent the nosing of the cars, to take as much weight as possible from the center plates and to put it on the side bearings. All of the weight would have thus been transferred had not the cars been designed with light side sills. It happens in this particular case that the distance center to center of the trucks was exceedingly small, but, even on long steel passenger cars, a saving in wheel flange wear would be effected by taking all of the weight from the center plates and putting it on the side bearings, that is, designing the truck so that immediately the car begins to take or leave the curve, an initial pressure is put upon the truck, which is thus slightly restrained in taking the curve.

This test has been carried out on several railroads. Plaster casts were made of the wheels, and it was found in making outlines of these casts that there is approximately 50 per cent reduction of the wheel flange wear when the radial movement of the truck was restrained in curving.

E. W. Summers.[1] In writing a ten-minute paper, it was not possible to go into detail to any extent. The examples given were intended to be only general in character. Of John A. Pilcher's criticism, the 1-in. wind in track in 50-ft. is the ideal condition. Cars cannot be built to operate only under ideal conditions. Wind in track of 4 in. to 5 in. in the length of a car is frequently encountered when the alignment of the rails is disturbed by water or weather conditions. It is the abnormal conditions that cause wrecks.

In making his comparisons, Mr. Pilcher has apparently neglected the action of springs which are included in the inclined-hanger arrangement. If the inclined hangers make vertical adjustment on account of the tracks being in wind, the springs will not have that to do. As a matter of fact, both the springs and the hangers make some of the adjustment, neither one doing all of it.

As evidence that the vertical reactions given by him are incorrect, compare the ordinary center-bearing truck under a freight car with an inclined-hanger truck such as illustrated in Fig. 1 in the paper, Suspension of Steel Cars, and used under a similar car.

The center-bearing truck must have side bearings, which will be located, say, outside of the wheels in line with the center of the side frame as located on the inclined-hanger truck. Any experienced railroad man knows that side bearings so placed on a center-bearing truck, under such a car, will cause derailment, even on comparatively straight track. On twisted track the weight of the car outside of the wheel uses the wheel as a fulcrum and relieves the load on the opposite wheel, allowing its flange to climb the rail.

It is a matter of record that new refrigerator cars which are comparatively rigid, having side bearings in line with the wheel, easily leave the rails where the track surface is warped.

Contrast these with the inclined-hanger truck having its side bearings outside the wheels and over the center of the side frames under an absolutely rigid all-steel box car, and note that these cars have traversed the worst terminal tracks that could be found at higher speed than the engineman dared to follow with his engine without any indication of wheel lifting, and it is clear that Mr. Pilcher's reactions are in error.

[1] President, Summers Steel Car Company, Pittsburgh, Pa.

As a comparison with his spring deflection taken from actual springs, some five years ago the writer built an all-steel box car equipped with side bearings directly in line with the truck side frame and M.C.B. springs for a 50-ton car. When attempting to take this car on its own wheels from the riveting shop to the paint shop at the works where it was manufactured it was derailed six times, due to the side bearings being outside of the wheels and warped track surface. The side-bearing, inclined-hanger arrangement was applied to this car, no change whatever being made in the spring arrangement, and the car then traversed the worst tracks to be found around the works and has continued in regular interchange service on the railroads ever since with no indication of derailment or torsional injury to the car body.

Now, it is clear that with six-wheel trucks weighing as much as a whole freight car, trucks and all, when under a passenger car body of comparatively light weight, the truck weight is sufficient to overbalance the outside load from the body side bearing. The conditions which cause freight car derailments, that is, load reaction on diagonal corners are, however, still in the passenger cars; the excessive comparative weight of the trucks with that of the car body prevent showing up the car body twist by derailment. The inclined-hanger arrangement relieves this twist. It makes it possible to carry the entire load on the side bearings, directly over the truck side frames. It does away with transverse oscillation or rocking and in so doing prevents nosing. With it, the heavy body and truck bolsters are not required as the load is dropped directly from the car side girders into the truck side frames.

INDUSTRIAL EDUCATION

By F. J. Trinder[1], New Britain, Conn.

Non-Member

In discussing the subject of trade education, engineers should be governed by the true spirit of analysis, and analysis of this subject will show that while it goes beyond the elastic limit or the ultimate strength of the physical bodies with which we are accustomed to deal, it nevertheless has a vital bearing on the successful work of the engineer, in that training in trade education gives to the manufacturing world constructive workers of pronounced ability, able to interpret correctly the design, and to construct loyally according to the principle laid down by the engineer, thus assuring a synchronizing of effort as against the work of men who simply grew up in the work of a mechanic without the quality of a systematic training.

For many years the education of the boy and the girl at public expense has been along lines laid out by instructors who saw only one side of the educational problem and with one result, that of formulating a common course of study for each grade or room and requiring both boys and girls to carry on the work, regardless of the needs of the individual for a more specific training in order to earn a living. Schools in a farming community had the same corrolation of studies as was used in manufacturing districts, and in many cases applied neither to the farm, business nor manufacturing, as the following problems show:

a If in a period of 72 days, 33 1/3 per cent are cloudy, and if it rains 16 2/3 per cent, how many days are rainy?

b If 20 per cent of the days of a common year are stormy, how many days are not stormy?

c John is 15 years old and his sister is 10. His age is how many hundredths more than hers? Hers is how many hundredths less than his?

Can a set of problems more useless than these be conceived?

[1] Superintendent, State Trade Education Shop.

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Is it any wonder the boy rebelled against such nonsensical abstract work or that he is determined to leave school and take his chances at some kind of work? To work at what? Certainly not at a specific kind of work for which the school has trained him.

Most engineers have prepared themselves for some specific line of endeavor, decided on the course to pursue and arranged the combination of elements that make for success. So it should be with our public schools and scholars.

The State of Connecticut is trying to solve at least one feature of this educational problem. The board of education in 1910 secured the passage of a law creating two trade schools and the legislature appropriated $100,000 for this purpose. After investigation as to the best locality for such schools, New Britain and Bridgeport were decided upon. The building at New Britain occupied by the boys is a mill construction of the saw tooth type, four bays with a floor space of 12,000 sq. ft. The light is ideal and ventilation and heating are easily controlled. The trades now taught are machinist, pattern-making, carpentry, drafting and plumbing, with plans partly under way for the trade of printing and bookbindery.

The machine departments of New Britain and Bridgeport have contracted to build a complete line of drill presses, tool grinders and small engine lathes. We secure from the factories what boys' work they can give us, for instance, bolts. These provide experience in rough and finish turning and threading. The same boys, having drawing and academic work in keeping with all shop work, learn to construct the various types of threads, also to calculate the dimensions of U. S. Standard bolts from diameter. Lectures are given in class rooms on planing tools, jigs and fixtures.

The pattern department includes both wood and metal work and orders are secured from the outside on new work and on repairs. Each apprentice must put his pattern in the sand, ram up his own mold and make a casting.

The carpentry department boys are now building a $4800 three-family house. It has progressed to the stage where the shingling and siding is completed, window frames set and porches finished.

The plumbing department boys have erected all soil pipe, pipes, traps, vents and lavatory connections and are now waiting

for the plastering to be done when they will proceed with the final fitting up of tubs, bowls, etc. The house is scheduled to be completed in ten weeks, provided the plastering and painting to be done by outside firms is not delayed. It is important and necessary to state that the plan of the house and drawings are also the work of the boys. One noticeable fact about this house building is that no one has been privileged to see greater energy and interest manifested by apprentices on any line of work.

Shop time is from 9 to 12, 12:30 to 5:30 every working day of the year except Saturday, when it is from 8 to 12. Class hours for academic work are arranged to suit the needs of the apprentices.

Regarding the system and shop methods: All work is built on a customer's order and to his specifications or that of our own. The apprentices make the drawings, tracing and blue print. Job tickets are furnished through the office on which must be recorded, first the estimate hours of journeyman's labor, and cost of material, then the actual hours of labor as recorded by the apprentice on his daily time card to be approved by the foreman. The efficiency of the apprentice is the result of the estimate in journeyman's hours divided by the actual hours consumed on the job. This gives the boys their percentage of efficiency in terms of journeyman's hours.

One very important requirement of both the instructor and apprentice is the training for speed as well as quality in the work. Often I am asked, "Do you believe in sacrificing quality for speed?" My answer is, "Give the work the quality it demands, no more, no less, but give it also the speed it demands in keeping with the best you can drill the boy to do." It is not fair to the young man you may have graduated from your industrial school if you have trained him with a view to quality of work only, and left out the speed training. If he is trained in both, his work will stand out and indorse your effort as well as his.

My advice is to get away from practice work. It has never trained the boy and never will. Instructors and some superintendents will tell you that just as good work can be done on practice work as on commercial work. Many instructors indorse it because they think there is no way to prove that it is not true. But I have tried it and I have proved my case. Many instructors indorse practice work because in this there is no customer to be

disappointed, or work to be turned back on account of defects. Was there ever a factory so successful that errors and defects never occurred? It may be that defects of a drawing are carried into a pattern; many patterns not made correctly to drawing; the error found in castings when ready to be machined.

A very important factor in the training of the boy, and one that is difficult to meet, is in securing the right kind of instructors. Several qualifications are necessary:

a He must be a clean good timbered man

b He must be a good mechanic in his line

c A man who can win the love and respect of the boy

d A man who will not tire in the day's work, but will keep moving. He must have "eyes in the back of his head" so to speak, and be gifted with a sense of the fitness of things by which to determine correctly if the boy is in the very best place suited to him.

e He must be a man with an analytical mind, strong in the principles of coöperation and a determination to obtain results.

I ask engineers to lend assistance in this work of trade education; to become associated with such educators as Mr. A. L. Rohrer, electrical superintendent of the General Electric Company, and Mr. Charles D. Hine of the State Board of Education, in promoting the efficiency of the work. The State of Connecticut is a manufacturing state; the people look to the manufacturer for employment; manufacturers are looking for trained mechanics and it is for us to find the shortest distance between the two points, the need and the supply.

The question of supplying trained workers is of vital interest to the United States, and if we hope to hold our own in manufacturing against Germany and other European countries, we must first be prepared to meet the demands for trained workers in all trades. This is no idle statement. It is a condition to be met now and we as engineers having to do with manufacturing will be confronted with a serious problem unless we give attention to this question of trade education.

In the girls' department of the trade shop is taught dressmaking, designing and millinery. The training of these girls has a vital bearing upon the home, that it become provident instead of improvident, happy instead of sorrowful, encouraging in place of discouraging, to the trained mechanic who may be chosen for a husband.

OVERHEAD EXPENSE DISTRIBUTION

By Royal R. Keely, Philadelphia, Pa.
Member of the Society

ABSTRACT OF PAPER

All expenditure in any industry may be divided into three broad classes, labor, material, expense; or more broadly, direct and indirect expense. Direct expense may be defined as all that may be charged directly to the product; indirect expense as all other expense connected with the conduct of the business and which must be borne by the sale of the product.

In a foundry, for example, the labor applied directly in producing a length of cast-iron water pipe is called direct labor expense; that is, it is the labor applied directly to the product of this piece of pipe and is in no way related to other articles that may be produced. The pig iron required in making the length of pipe is direct stores expense. Other labor connected with the administration or supervision is classed as indirect expense. Stores required for repair of building and equipment, office supplies, etc., are classed as indirect stores expense.

In order that the management may intelligently conduct any business, the cost of each article of product should be known. In determining the cost of the length of cast-iron pipe referred to, the labor applied directly in making it, as for instance, the setting up of the mold, pouring of the metal, removing of the pipe from the mold and cleaning it of sand, etc., and the pig iron entering into it, may be charged directly to its cost. But since all expense of the conduct of the business must be borne by the product, this individual length of pipe must bear its share of the expense of supervision, taxes, insurance, depreciation, repairs, heat, light and power, selling and advertising, general office expense, etc.

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The determination of just what its share of these expenses should be has aroused much controversy, and there are in use today six methods of determining this indirect or overhead expense: (*a*) in proportion to material used; (*b*) in proportion to the direct labor charge; (*c*) the time or number of man-hours employed in production; (*d*) machine rates; (*e*) cost numbers or factors; (*f*) prorating by inspection or judgment.

The first of these may be satisfactory if the product is homogeneous, as brick from a brickyard, where if any one kind of brick constitutes one-tenth the product of the plant, this will take one-tenth of the total overhead expense.

The second, that of apportioning expense according to wages paid, is very generally used. Here, if the direct wages paid on any kind of cast-iron pipe are one-tenth the total direct wages for the foundry, then this kind of pipe bears one-tenth of the total overhead expense. The objection to the method is that a job produced by a 40-cent man at a vise and bench would bear the same proportion of overhead expense as one produced by the same man on a large and very expensive machine. This method will be sufficiently accurate only in cases where the workplaces are all of nearly equal value and capacity and the workmen paid fairly uniform wages.

By the third method overhead expense is apportioned by the time spent on the job, instead of the value of the time, as in (*b*). It also does not take account of the equipment.

In the machine hour, or the workplace hour method, the rate is figured to include all expense of maintaining and operating the given workplace, a term broad enough to include everything, from an allotted area where a man may work with a monkey wrench or paint brush to the most complicated and costly machine in the shop.

In a modern office building the income-bearing unit is the office room to be rented, and in fixing the rental account must be taken of all the overhead expense. In a machine shop, each workplace may be regarded as enclosed by four imaginary walls, forming a room of suitable size for the performance of its operation. Each workplace is then considered as a unit in itself from which profit may be made in turning out a product, or it may be rented to an individual workman.

If all the workplaces are rented, then the source of income is not on product sold, but altogether from rental on the available

useful space of the manufacturing plant. All space, however, cannot be turned into rentable workplaces, for there must be general heat, light and power plant, storage space, aisles, halls, passages, offices, etc. The rented space, therefore, must not only maintain and operate the entire shop, but must produce a profit for the owners. Each workplace unit must bear its share of interest and depreciation on its building, interest and depreciation on the cost of machine, taxes, insurance, etc., on the investment, repairs and maintenance of building and equipment, its share of heat, light, power, etc., as well as all other general charges, if it is to make a profit for its owners.

The cost of the product from each workplace is made up of rental, raw material entering into the product, and a fair compensation for the worker, and the selling price must include his profits. The rental of each workplace must be a figure that will enable its operator to make a profit and must at the same time pay all the owner's expenses and make a profit besides. Provision must also be made for the idle time of a workplace.

This indicates the method of arriving at the machine rate. The method is superior to the others in that it takes account of the variation in the cost of production on different types of workplaces, and would be accurate if there were no idle hours. In any system the wages are very carefully charged directly to the item of product, but since the general charges of interest, depreciation, insurance, etc., may be equal to or greater than the wages, it is important to cut these down to a minimum by putting as great a proportion as possible directly against the particular items of product, as in this method.

Mr. Church in his book on Expense Burden, advocates a supplementary rate to dispose of the expense connected with the idle hours and the auxiliary departments, as shipping room, store room, etc. By this plan, expenditure is connected with production centers, the charges being debited to jobs by machine rents or rates so carefully arranged as to include all of them. All floating or general items are collected into a monthly shop-charges account, which is relieved by the total of charges which have been debited during the month by means of machine rates, leaving in the account a residual sum. This sum is reduced by the supplementary rate to an hourly burden, distributed over the jobs in the usual way.

To quote from Mr. Church himself: "It will be obvious that

by this means all the charges will be distributed, leaving nothing in the charges account, and that if all the machines have made full time in the month, the supplementary rate will only represent the floating shop charges. In proportion as machines are idle the supplementary rate will rise, because only working hours are credited to the shop account as per the total of the machine rates found at the end of the month. Thus we secure that each job gets its own expenses only attached to it, plus an average of floating charge and of what surplus may be due to slack times or inefficiency in the shop."

Again he says: "The idleness of a machine may or may not be considered as the fault of that machine. If, for instance, a machine was found to be idle nineteen-twentieths of its time, this might be due to one of two causes. Either the process was rare but essential, or the machine itself was largely superfluous. In the first case it would be eminently fair that the charge should be made very high when it was put in use, since the shop charges due to its presence and upkeep are indubitably incurred for the sake of this occasional use. In the second case it might be rather a matter of accommodation that the machine was retained at all, in which case the shop as a whole should bear the burden and not the unlucky piece of work that should happen to be put on such machine at that time." It is thus seen how this ingenious method puts to each item of product its proper share of overhead charges, for the workplaces which are in use. Then the balance left over, due to idle machines and other auxiliary and general expense, is prorated by a supplementary rate.

In the fifth method, that of cost numbers or factors, which is a simpler system worked out by Frederick W. Taylor in his study of scientific management, the machine rates are determined by a process similar to that already described, and the rates are then treated not as a figure of value, but as a relative number called "relative cost numbers," or simply "cost numbers." If the cost of maintaining and operating two machines is three cents and three dollars per hour respectively, the cost numbers will be three and three hundred respectively. The number of hours each machine runs on any job is multiplied by its cost number. At the end of the period, the total hours by cost numbers for each article or class of product on which it is desired to compute costs and also for the entire shop, are added together. The result obtained is about the same as that reached by Mr. Church's

method, without the complication and extra work of apportioning a second time for the supplementary rate.

In general a rate for apportioning the overhead expense can be established by this method for any class of product and the variation of the rate from period to period will give an accurate indication of the percentage of idle time in connection with this product. The disposal of all shop expense is now provided for. There will be few difficulties in the way of putting the direct labor and stores charge against the article of product into which it enters.

The writer generally accomplishes this result by assigning to the product and stores a definite, concise symbol for each size and kind. The mnemonic system of symbolization, as developed by Mr. Taylor, gives most excellent results. All expense in connection with the conduct of a business is divided, into (*a*) auxiliary, or "A" accounts, as power, stores, shipping, planning, etc.; (*b*) business office, or "B" accounts; (*c*) sales department, or "C" accounts; (*d*) manufacturing departments, or "D" accounts; (*e*) machinery and equipment, or "Y" accounts; (*f*) real estate, or "Z" accounts.

The expenses in connection with the A, D, Y and Z accounts are shop expenses and are disposed of by the method of hours by cost numbers, already described. B and C have no direct relation to shop costs and the expense of these departments may be disposed of by another method to be considered presently. All labor is apportioned by a system of job cards, time stamped at the beginning and again at the end of the job. The sum of the time shown on all these cards must equal the time for which the workman is paid. There is only one job on a card and each card bears the symbol of the product to which the time is charged. The stores are issued from the store room on similar cards. During the period all job cards and stores issue cards are accumulated by symbol in a card index file. At the end of the period the total of all money paid, as represented by the cards, is drawn off by products.

In the classification of expense there is a symbol for each item of expense, both direct and indirect. The direct labor and stores can now be entered at once on the cost card for product turned out. The indirect labor and stores are entered on expense distribution cards, together with other indirect charges, as taxes, insurance, depreciation, etc.

The selling and business office expense, B and C, may be apportioned by a different method, either by direct shop cost, by wages, or by the time consumed in the manufacture of the product, according to the nature of the business. In some cases it may be merged with the shop expense and the total prorated by the method outlined. The usual method is by direct labor cost, or by hours of labor consumed in production.

The sixth method of apportioning the overhead expense, i.e., by inspection or judgment, is one in which the experience and judgment of officials of a company are used in putting this expense where it belongs.

To arrive at a practical method for doing this, the principal items of expense, which may include advertising, catalogues, correspondence, legal expense, patents, traveling expense, salesmen's salaries, drawings, etc., are listed and the expense of each apportioned to each class of product in proportion to the benefit derived, the proportion being determined from inspection. Thus, it may appear that advertising expense should be distributed among four different products as follows: 10 per cent to the product *A*, 20 per cent to the product *B*, 30 per cent to the product *C*, and 40 per cent to the product *D*. Product *A* may be an old and staple article, having a general demand, while *D* may be a new and patented article for which demand must be created by advertising.

If the profit on any class of product is exceptionally high or low, it will call for a careful examination of the direct and prorated charges. The direct charges of stores and labor are very definite items and on these there can be little question. The indirect charges, especially those in connection with business administration and selling, are very intangible and hard to connect with any expense of manufacture, but it must be remembered that every dollar or expense, both direct and indirect, must be borne by the product which is made and sold.

The method of Hours by Cost Numbers for all shop expense and that of apportioning by inspection for selling and business administration expense, are most generally applicable to the ordinary manufacturing establishment.

DISCUSSION

William Kent, in a written discussion, described a seventh method of prorating overhead expense, namely a combination of

the first and second, prorating the expense in proportion to the sum of the material and labor costs.

For example, suppose that in a given time there are two products made, A and B, the first costing \$100 for material and \$50 for labor, the second \$50 for material and \$100 for labor, the overhead charges, or burden, for the two together being \$150. By the two methods of prorating given by Mr. Keely, (a) in proportion to the material, and (b) in proportion to labor, the cost accounts would show the following:

	A	B
By method (a)		
Material	\$100	\$ 50
Labor	50	100
Burden	100	50
Total factory cost	\$250	\$200
By method (b)		
Material	\$100	\$ 50
Labor	50	100
Burden	50	100
	\$200	\$250
By the combined method we would have		
Material	\$100	\$ 50
Labor	50	100
Burden	75	75
	\$225	\$225

Still another modification would be to charge material and credit burden with a certain percentage of the material cost, to cover storage and interest on capital invested in the material, and to apportion the remainder of the burden in proportion to the sum of the labor and of the material cost thus enhanced; thus, if 20 per cent is added to the cost of material, the account would stand

	A	B
Material	\$100	\$ 50
Add 20 per cent	20	10
Labor	50	100
Sum	\$170	\$160
Remainder of burden prorated	62	58
	\$232	\$218

Whether any of these methods, or the machine hour, or cost num-

ber method should be adopted in any particular plant depends on the nature of the business, and on the object that is to be obtained by the cost system.

Regarding the length of cast-iron pipe, assuming that it is only one of a hundred kinds of castings that the foundry makes, it is impossible to apportion precisely its share of the expense of supervision, taxes, insurance, depreciation, light, power, etc. Suppose the piece of pipe is not a regular product of the foundry, but only an occasional one ordered by a neighboring shop, the order being accepted at a very low price because the foundry is short of orders at the time. The book-keeper reports that money has been lost on that pipe, and presents the following account: Material, including waste, 1 cent per lb.; labor 0.5 cent; burden 1 cent; total 2.5 cents per lb. Sold for 2 cents; loss 0.5 cent. The owner says, "I think we have made money on that order, for the cost for labor and material was 1.5 cents, and the selling price 2 cents, leaves a margin of 0.5 cent to apply to burden. It cost nothing for selling and advertising, and the expense for supervision, taxes, etc. would have gone on if we had not taken the order." Six months later the order is repeated, when the foundry is full of profitable orders, and the price is made 3 cents, not because the cost including burden is 2.5 cents and 0.5 cent is wanted for profit, but because that is "the price the market will bear."

The following is a system of making an estimate of a machine-hour cost. Assume a large and expensive machine costing $2000, which is in use a different number of days each month. The cost-clerk may present the following tabulation of annual burden charges to be made against it:

	Cost while Idle	Additional Cost while Running
Interest, 5 per cent on $2000	$100	
Rent, 100 sq. ft. at 50 cents	50	
Taxes, 2 per cent on half value	20	
Insurance, 0.5 per cent on value	10	
Light and heat (in winter only)	20	
Depreciation (obsolescence and corrosion), 5 per cent	100	
Repairs or depreciation due to wear, 2 per cent		$40
Lubrication and cleaning, say		10
Power, 2 h.p., estimated load factor 0.25; 2 × 3000 hours × 0.25 × 2 cents per h.p-hr.		30

Superintendence, office expense, etc. Total $20,000, share of this machine, 0.5 per cent		100
	$300	$180
	180	
Total	$480	
Add for contingencies 25 per cent	120	
	$600 or $50 per month	

Charge $50 per month
2 per day if running 25 days per month
5 per day if running 10 days per month
10 per day if running 5 days per month
Labor costs $3 per day for each day the machine runs

Days run in a month	5	10	25
Labor cost at $3	$15	30	75
Machine hour cost	$50	50	50
Total	$65	80	125
Number of units of product made	50	100	250
Cost per unit	$1.30	0.80	0.50
Suppose these units are sold so as to net the factory 80 cents each			
Loss, each	0.50	0	—
Profit	—	—	0.30

Or suppose these units are parts of a finished product, shall they be billed to that product, 50 units at $1.30, 100 at 80 cents, 250 at 50 cents, plus the charge for material (whatever it may be), making it appear that the cost of the product varies from month to month according to the number of idle days of a certain machine during a preceding month?

A far better way is to have a fixed hourly charge for the machine in question, which is not changed during a whole year. For example, it may be estimated that the machine will be in use 150 days in the year, averaging $12\frac{1}{2}$ days per month. The daily charge then will be $50 \div 12\frac{1}{2} = \$4.00$, and if the work day is 10 hours, 40 cents per hour. The cost of these units will then appear as follows:

Days run in a month	5	10	25
Labor cost at $3	$15	30	75
Burden at $4	1820	40	100
Total	$35	70	175
Number of units made	50	100	250
Cost per unit	$0.70	0.70	0.70

This plan not only saves the book-keeper's time in figuring the hourly cost each month, but makes a fairer charge to the finished product of which these units are part, which product should not be charged with the accidental idleness of any one machine.

We can get the percentage of idle time directly for each machine by summing up from the time cards the number of hours credited to it in each year, or month if need be. Assuming that the machine should run 12½ days on an average to earn \$50 per month, the table last given shows that we lost \$30 on it the first month, \$10 the second, and gained \$50 the third.

I wish especially to emphasize the inadvisability of charging to a machine hour any part of the selling expenses, advertising, etc. The machine hour is part of the factory expense, and should not be charged with losses due to inefficient salesmanship. The sales department should be considered as a separate business from the factory, and should have a separate system of accounts.

Harrington Emerson said that cost records should not be given undue prominence as they are of value only when they foretell the future. Most modern cost accounting records the mistakes that have occurred but does not prevent future mistakes. Cost accounting to be of assistance must predetermine the standard cost of every item of material, of labor and of capital charge, and at the time the work is progressing check the actual against the standard.

Cost records are only one of many forms of efficiency records. A vast sum may be expended in some enterprise and the books recording the various transactions involved may balance to a cent; but this fact affords no indication of money that may be worse than wasted through inefficient materials, labor and equipment.

Standard costs of operation are not attained because in the first place the great majority of men are low in industrial efficiency. Beyond this, however, the standard is not attained because of the complexity of modern conditions, which introduces a dependent sequence, so that each is dependent upon that which follows. As a result, very slight inefficiencies grow in a dependent sequence into big inefficiencies in end results and very slight improvements in separate acts result in enormous gain. Because men are inefficient, single operations are inefficient, and through dependent sequence appalling wastes result. In every single operation, both for men and machines there may be (*a*) an over-

supply of hours or material; (*b*) a wasteful use of either; (*c*) too large a payment for the quality used; or (*d*) use of the wrong quality.

We may have ten men and ten machines and work for only six sets of them. The efficiency of supply will be only 60 per cent. One of these men may waste one-quarter of his time, but work with standard activity the other three-quarters, giving an efficiency of 75 per cent. The machine may have an efficiency of stroke of 80 per cent; of depth of cut, 50 per cent; of feed, 30 per cent; and of speed, 40 per cent, making the end efficiency of the machine only 4.8 per cent. The combined efficiency of use

FIG. 1 DIAGRAM SHOWING DIFFERENCE IN ACTUAL COSTS ATTAINED IN WORKING WITHOUT STANDARDS AND WITH STANDARDS

of men and machines will be only 3.6 per cent, and the combined efficiency of use and supply only 2.16 per cent. The man and machine may be 20 per cent more expensive and both twice as good as they ought to be for the job, giving therefore an efficiency of assignment, 50 per cent; efficiency of price, 80 per cent; efficiency of use, 3.6 per cent; efficiency of supply, 75 per cent; and an end cost efficiency of only 1.08 per cent. This particular single operation as to labor charge and equipment rate is costing almost 100 times as much as it ought to.

In two diagrams the difference in actual costs attained in work-

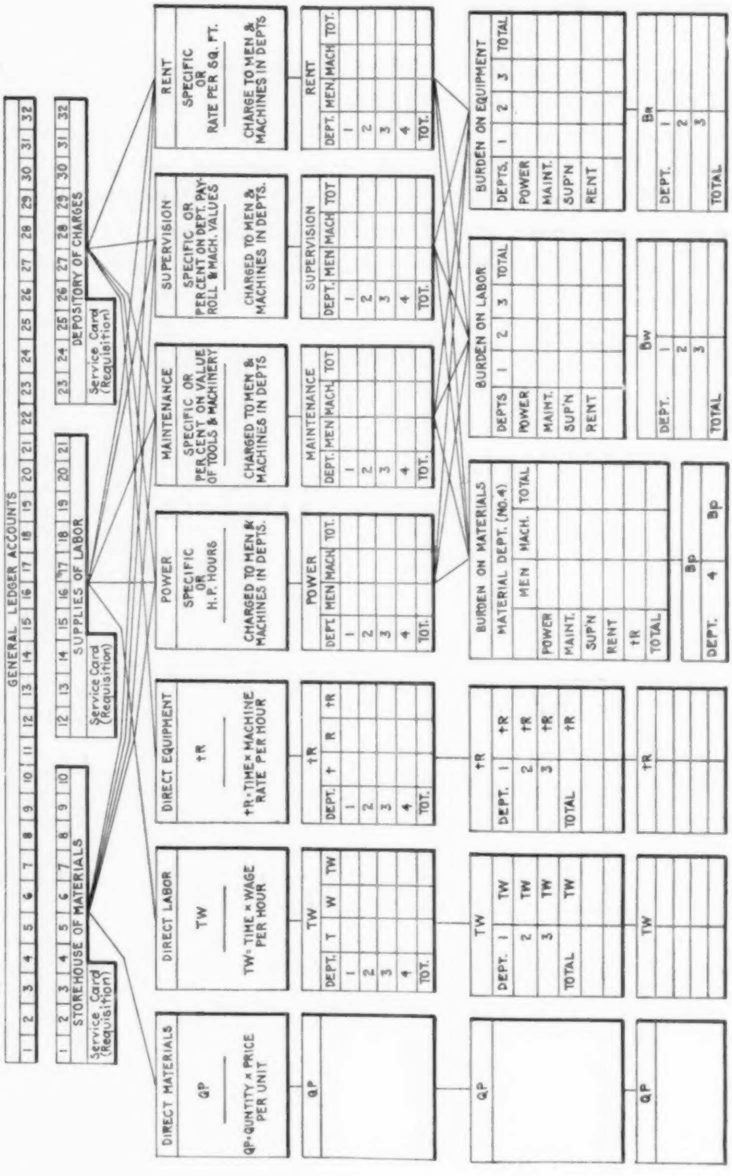

FIG. 2 GENERAL PLAN FOR MAKING EFFICIENCY STATEMENTS AND CONVENTIONAL METHOD OF USING RECORDS FOR STANDARD AND ACTUAL COST RECORDS

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ing without standards and with standards was shown (Fig. 1) and a general plan for making efficiency statements and a conventional method of using efficiency records for standard and actual cost records (Fig. 2). This latter is so simple that it can be put on a 5 in. by 8 in. card, and may be used for recording anything from the cost of a hook and eye to the operations of all the railroads of the United States for ten years. The formula is made up of three parts, materials, labor, and equipment operation.

This record will show both standard and actual costs as to every item. Actual costs are standard costs with an inefficiency per cent added. This per cent is generally that of the previous month so that actual costs can always be predetermined. Any difference between predetermined costs and moneys spent is very slight and can be easily adjusted.

In the general discussion which followed HENRY HESS said that knowledge of costs in every item was needed and that machine methods could not be substituted for individual personal management. Where a plant is too large for the supervision of one man, a number of men should coöperate in the management.

Both F. G. COBURN and WALTER M. KIDDER[1] emphasized the necessity for simplicity of method. Mr. Kidder thought that if it were borne in mind that the principle of overhead must be applied in proportion to the amount of production capacity consumed in the production of a given article, and a practical method that will approximate this result is sought, that a useful cost method would result. CARL G. BARTH also disapproved of any method which required a complicated mass of figures.

J. F. WICKERSHAM[2] described his experience with the New York Shipbuilding Company where a very detailed cost record was kept with satisfactory results.

Following a line of argument suggested by Mr. Barth, F. C. ANDREWS[3] said that the question of how much the selling price could be cut to allow a margin of profit was a most important one. In some plants it would take five or ten times the cost in clerical hire to keep track of the cost records, and selling from

[1] 127 West 56th Street, New York.

[2] Care New York Ship Building Company, Camden, N. J.

[3] Industrial Engineer, 1707 Arch St., Philadelphia, Pa.

the lowest list prices agreed upon by other manufacturers and with discounts is a satisfactory method.

A. C. Jackson described methods of distribution by the aid of lantern slides and Mr. Barth showed blueprints illustrating tables of costs.

The Author concluded the discussion by emphasizing the necessity of some basis for the distribution of costs. Simplicity was desirable, he considered, if it could be attained, but with a complicated product a complicated method of cost-keeping is necessary. The rule should be to use as simple a method as possible consistent with the results to be attained.

PORT FACILITIES FOR SHIPS AND CARGOS IN THE UNITED STATES

By William T. Donnelly, Brooklyn, N. Y.

Member of the Society

ABSTRACT OF PAPER

One of the most important of the controlling factors in marine transportation is the dispatch of vessels and cargos from one place to another. Therefore, any facility which will tend to increase the amount of cargo moved in a given time while a vessel is in port will increase the number of trips the vessel can make. To this end, port facilities must be provided for the unloading and loading of the cargos. They embrace the harbor, piers, railroads, floating harbor equipment and all the minor appliances, such as storage, rehandling and transfer facilities.

One of the fundamental differences between European and American ports is that nearly all of the former are at considerable distances from the sea, at the heads of navigation of rivers, while most of the latter are on the sea coast. This brings about an entirely different situation relative to the port facilities and therefore, it is not practicable to compare the port of Hamburg with the port of New York, and the methods and devices used in the one city are not at all adaptable to the other.

Another fundamental difference is brought about by the fact that the port of New York, while by far the largest of any in the world, is not the home port of any of the great trans-Atlantic steamship lines, and it is very plain that a company owning ships will make greater investments for port facilities at home than abroad.

Perhaps the greatest difference, however, is due to the extent to which lighterage is used at the port of New York. Manhattan Island is reached direct for freight purposes by only two of

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the many railroads that extend to the harbor front and access to Manhattan Island, Long Island, Staten Island and the adjacent waters is brought about by a very extensive system of harbor transportation known as lighterage, by which freight is moved at a minimum cost and with the greatest flexibility. A part of the equipment for this system consists of car floats, by means of which direct interchange of cars can be made between any of the railroads and access can be gained to freight terminals at any desired point on the waterfront. These car floats were originally designed for ferrying purposes, but it was soon discovered that they formed one of the most flexible devices for freight handling in and about a large marine terminal, and they must now be considered one of the most important features of the port of New York. In fact, so valuable are they to the railroads, that piers devoted exclusively to the loading and unloading of cars on floats have been taken over one after another along the lower part of Manhattan.

The principal difference to be noted between New York piers and those abroad is the absence on this side of heavy lifting machinery, which is always a prominent feature of the foreign ports. This has been brought about by the development of the lighterage business and more particularly by the adaptation of floating derricks for handling all heavy weights from lighters to ship's hold and from ships to lighters and then to the pier head or bulkhead for rail transportation or delivery in the city. This particular branch of transportation is an American feature and owes the extent of its development to the use for apparatus primarily designed and developed for wrecking purposes.

In the practice of this port, only the lighter portions of the cargos are handled over the ship's side on to the piers; that is, objects weighing a maximum of two tons, such as are readily handled by ship's winches and similar winches located on the pier. A fixed or traveling crane located on a pier can serve but one ship and often not more than a single hatch of that ship, while a floating derrick or lighter may move from ship to ship and from one part of the harbor to another and find much more constant occupation. It is also often found that the cost of handling freight over the ship's side from lighters is less than handling it across the pier, and it is the practice of the steamship companies to encourage the delivery of as large a quantity of goods as possible by lighter.

Consideration has been given to the matter of bringing the railroads and steamships close together, but wherever this has been tried it has been found impractical. Many piers are built with railroad tracks running down the center, but few cars will be found at any time on the piers. This is owing largely to the fact that a freight car is an awkward object to move about and that it contains a comparatively small quantity of goods; also, that the shifting and moving of the freight cars interfere with the work of handling material on the pier. Of course, this does not apply to goods that can be delivered by the carload, such as grain, coal and ores, for such materials do not come to the steamship piers referred to, but to special piers devoted entirely to their reception, where they are handled by machinery at as low a cost in this country as anywhere in the world.

The coaling of ships in the port of New York is of a somewhat unusual character, and to a certain extent affects the method of freight transfer. Coal is brought to the ship's side in canal boats approximately 20 ft. beam and capacity from 400 to 600 tons. To expedite the coaling it is done on both sides of the ship; that is, first on the off-shore side and then the ship is breasted out or moved some 20 ft. or 25 ft. from the pier and the coal boat moved in between the pier and the vessel and the bunkers filled on that side. It is apparent that cranes fixed on the pier during this time would have to extend some 25 ft. further, while the ship's winches, working in connection with a similar winch on shore, can transfer freight without interruption. These winches are designed to handle from one to two tons on a single line, and to be operated by the ship's crew and with whatever assistance is necessary from the shore.

It would seem that there is small probability of other mechanical appliances superseding this method in this port when freight is to be hoisted from a ship's hold. When freight can be delivered from a gangway at or below the pier level, mechanical devices to assist stevedores with handtrucks on grades have been found practical, and these devices are also much used to carry freight to and from lighters which bring a considerable amount of material to the piers for storage and trans-shipment to vessels.

No discussion of port facilities would be complete without some consideration of the matter of facilities for getting the freight to and from the steamship piers; that is, should the railroads deliver the material in cars on the piers or to the terminal

adjacent thereto, and to what extent and how should the railroads and waterfront be tied up together?

The Atlantic freight and passenger transportation at the port of New York has had its greatest development on the west side of Manhattan Island, and it is over this waterfront that it is necessary to transfer between ship and railroad and ship and factory vast quantities of merchandise. Owing to the fact of its isolation, it is reached directly by but a single railroad, and the situation has been aggravated by the fact that this shore front is connected with the terminals of railroads across the Hudson River by many passenger ferries.

As the Atlantic transportation business has grown, congestion along the waterfront has been steadily increasing. To meet this, the railroads terminating in Jersey City have adopted the practice of leasing the piers along the lower Manhattan waterfront and using them for the receipt and delivery of railroad freight which, of course, results in the exclusion of trans-Atlantic and coastwise commerce from these piers. This condition is looked upon with disfavor by the steamship lines and also by the dock department, which has at heart the best interests and most desirable use of the waterfront for marine transportation. It also results in great congestion of the piers and West Street from trucks bringing and removing freight.

An independent study of these conditions some time ago resulted in the Bush Terminal development at South Brooklyn, which is the most remarkable any city has ever seen. Investigation first developed the fact that the congestion and greatest avoidable waste in freight transportation in and about New York was due to the trucking. But the real principle involved is the fact that every considerable producer of merchandise has to ship goods not by one railroad or steamship line but by nearly every one, which necessitates his trucks visiting almost every day eight or ten different points for the delivery of one or two cases of goods to each. The impossibility of merchants and truckmen working together leads to endless confusion, congestion and delay at the points of shipment.

To obviate this condition, the Bush Terminal Company provided on the South Brooklyn waterfront float bridges where not only one but all the railroads could deliver freight cars to shore tracks, and a car-distributing yard on their own property, from which the cars could be delivered as required alongside factory

buildings so as entirely to eliminate not only trucking charges, but also unnecessary delays and confusion in shipping. The company also created a system of piers backed up by storage warehouses for the receipt and storage of raw material and also for the storage of finished material to be accumulated for shipments abroad. The result is the most perfect system of rail and marine freight handling, manufacturing and redistribution that has been accomplished to date anywhere in the world. All confusion and interference has been eliminated and congestion is unknown, and the general plan is being studied and copied in many parts of the United States.

The same arrangement applied to the Manhattan waterfront would bring about a satisfactory solution of the problem, if it were not for the congestion resulting from necessity of access of great numbers of people to the waterfront. It has been the people's contention that their safety is of the first importance, and that consequently no additional railroad facilities should be allowed upon that waterfront and even that those existing should be removed. To this end, the dock commissioner has prepared an elaborate plan for moving the railroad tracks from the surface to an elevated structure along the waterfront accessible to all railroads. This plan, however, involves an almost insurmountable difficulty in the grade to be overcome in raising the cars from the water level to from 25 ft. to 30 ft. above, and the additional expense of supporting freight cars and locomotives upon an elevated structure.

Primarily, it would seem that the object to be attained is the separation of the passenger and freight transportation, and it would appear that this could be brought about at much less expense by elevating the passenger traffic at and along the waterfront; that is, by treating the Manhattan waterfront exactly as the Brooklyn waterfront, and then, for the passenger traffic which must be provided for, create an elevated street or highway adjacent to and along the front of the piers on West Street to be used exclusively for foot passengers and vehicles for passenger transportation, to be reached at various points which might be every third or fourth block, by ramps of a grade such as to be unobjectionable to foot passengers and vehicles.

It would then be possible to give all the railroads free access with cars to West Street and eliminate all danger to foot passengers. The railroad and terminal companies could then take up

and develop the property on West Street, and the cars would be run from West Street directly into these terminals for loading and the car floats would disappear from the waterfront except at the float bridges. By this modification, it would also be possible to distribute the car float bridges along the waterfront, which it is believed would be more practical than to have them all at one point.

DISCUSSION

H. McL. Harding[1] in a written discussion gave a detailed description of the various methods now in vogue for the mechanical handling of freight to and from vessels at ports both in the United States and abroad, including the gantry crane, the ship's winch and the transfer hoist.

At the foreign ports equipped with transferring mechanism for miscellaneous cargos, the gantry crane is everywhere in evidence, not only in Germany, England and France, but also in Japan and at the South American ports. The rapidity attained by this crane within its limited range is remarkable, and this is regarded as of more importance than economy of labor. There has been discharged from the ship's hold upon the piers by one electric crane 134 tons of miscellaneous freight per hour. This embraces about 45 to 60 cycles per hour with loads varying from 1 to 3 tons for the following cycle: hoisting, 40 ft.; swinging, 150 ft.; lowering, 20 ft.; and then hoisting, swinging back and lowering the hook to the starting point.

In one example the total working expenses for 400 tons discharged by electric cranes, with current at 5 cents per kw-hr. and including interest upon capital, depreciation, operators' wages, lubrication, etc., amounted to less than 2 cents per ton, discharging from the hold of a vessel and delivered upon the pier. It will be seen that at an expense of 2 cents per kw-hr. for electric current, the cost would be not over 1¾ cents per ton. Mr. Broughton states in the London Electrician that with electricity at 2 cents per h.p-hr. the total expense of the crane work in discharging 1000 tons of general cargo with cranes of 3 tons capacity was about $4.13, or less than ½ cent per ton. This is on the basis of lifting the load 30 ft., slewing 100 deg., lowering 30 ft.

In order to get the best performance in hoisting, there should

[1] Consulting Engineer, 17 Battery Place, New York.

be rapid acceleration, uniform motion at high-speed and quick retardation. There is excellent economy attained in rapidity and economy in the operation of the gantry crane. Its limiting factor is its range of operation, being able to serve only a semicircle of a diameter usually not in excess of 40 ft., or perhaps limited to a quadrant of a circle of this diameter.

By suitably arranging the jibs of the cranes, three gantry cranes can simultaneously lift the cargo, which has been raised out of a ship's hold by the ship's cranes, from the deck or from an extended platform, or even from the side of the piers, or in the usual way of burtoning. On projecting piers, as along the New York waterfront, averaging 125 ft. in width, if a gantry on each side takes up 40 ft. there would be room only for a shed 45 ft. in width. To obviate this difficulty, long jib gantries are placed upon the roof, as at Bristol and Liverpool. These, however, do not serve the interior of the sheds advantageously.

In the United States, as Mr. Donnelly has stated, the ship's winch is almost exclusively used for miscellaneous cargos, although on many coastwise ships, the winch is supplemented by trucking through the side ports from between decks when the tide is favorable. Even when the side ports are used, the winch is employed for cargo from the lower hold, although in some cases the winch is used to raise from the lower hold to between decks, and the load then swung clear of the hatchway and hand-trucked through the side ports. Advocates of the winch state that it is cheaper than trucking through the side ports, and figures seem to substantiate this, but the advantage of trucking through the side port is that there is less congestion than when the winch is the exclusive method.

The weak point of the ship's winch is congestion on the side of the pier, even when the draft is burtoned or when there is an inclined gang-plank. It may be said that there is even more congestion when the plank is used, though it increases the distance from the edge of the pier where the draft can be placed. The drafts are deposited in the little space upon the side of the pier opposite the hatch which is being unloaded, which is about 7 to 8 ft. long and about 7 ft. wide. An individual draft will average less than two boxes, though it may comprise six boxes, varying from one to six marks or cross-marks, and provision must be made for all conditions or circumstances. There are sometimes three winches working at the same hatch; and the weights of the

individual drafts and the number per hour would compare favorably with the operation of the gantry crane, were it not for the congestion produced on the side of the pier due to the area being so limited, and for the necessity for distribution according to the number of shipping marks and cross-marks. There are about 40 drafts per hour with an average load of $1\frac{1}{2}$ tons. This congestion prevents a discharging capacity equal to that of the gantry cranes.

The cost per ton of swinging upon the side of the pier by the winch is about 3 cents. The second movement, including distributing to the various portions of the piers, assorting and tiering, averages about 30 cents per ton; this includes very little tiering, only to about the usual height of 5 ft.

It will be noticed that neither the ship's winch nor the gantry crane, either separately or combined, fulfils the conclusion of the Association of Navigation Congresses at its Philadelphia meeting in May 1912, to the effect that "all the terminal area must be served mechanically," that is, that every cubic foot (not square foot only) within the terminal area must be served by machinery so as to avoid rehandling, and that there must be continuous rapidity.

Mr. Harding then referred to the third method of freight handling now being adopted along the German rivers, which may be called the transfer hoist. This consists of a tractor, suspended from an overhead track, and three trailers or more drawn by it, forming a train. Each trailer consists of a hoist suspended from wheels engaging the overhead track. The tractor and hoists are all controlled by a transfer man in a closed cab. There are in general fixed side tracks and movable cross tracks. The movable tracks are supported from a traveling crane, either of the shop or gantry type, and are either between the fixed side tracks of the shop crane, or in the form of a loop when supported from the gantry crane.

By means of this arrangement of fixed and movable tracks all cubical area can be served the same as with a shop crane, but with the addition of continuous rapidity. These transfer-hoist trains, moving along suitably planned fixed and movable tracks, in combination with the ship's winch or with the traveling gantry along broad quay walls, or even in combination with the so-called "cargo hoists," will enable the conclusion of the Navigation Congress to be satisfactorily fulfilled. The ship's winches will

hoist from the hold through the hatchways above the ship's deck, and from there the transfer hoist by burtoning will convey and lower to any part of the terminal, traveling suspended from the overhead tracks. Provision is made for distribution and assorting, each hoist generally conveying only one consignment.

For the transference of miscellaneous cargos, the gantry crane, though possessing great rapidity and economy of operation, is not suitable for narrow projecting piers on account of the room necessarily occupied if located upon the pier floor; if upon the roof, it does not serve the interior of the shed satisfactorily, while for the larger ships, its reach is not sufficient to serve the holds; this is especially true when they are breasted out 20 ft. or more. Its range, though much greater than the winch, does not serve sufficient terminal area. For cargos of but few shipping marks, of the smaller ships berthed along quay walls with car tracks under or adjacent to the gantry crane, the results are excellent, though its range of service is still limited.

The ship's winch is economical and rapid in operation, but its range is exceedingly small and its rapidity of operation is limited by the congestion occurring at the place of depositing. In combination with other appliances, as described, its rapidity is increased and the congestion removed.

The transfer hoist in trains, with fixed and movable overhead tracks in combination with the ship's winch or with the gantry crane gives rapidity, economy, and the serving of the whole terminal area, and also provides for distributing and assorting.

Harry Sawyer[1] took up the question of congestion in the streets. He said there were various ways of overcoming it: by reducing the amount of freight handled, by distributing it over longer periods of time, by distributing it over greater area, and by handling it at a higher rate of speed.

The first was certainly not the solution as the quantity of freight handled could not be reduced, but more and more freight had to be handled all the time. Of the remaining methods the distribution over longer periods of time could be obtained if transportation companies would take freight from the shipper's place of business and deliver it to the consignee as express companies do. Motor trucks could make regular trips through the city delivering and collecting freight. This would reduce cost as well

[1] Consulting Engineer, Shaw Electric Crane Co., Muskegon, Mich.

as save congestion of streets for fewer trucks would be required and they would go loaded both ways. A great amount of travel with small or no load would be saved.

The means of saving congestion by distributing the work over a greater area could be made very effective. A series of local freight stations should be provided with a railway system for local distribution. With such a system long hauls to and from steamship piers would be avoided. The short hauls to the nearest local station would save both in expense and street congestion.

Mechanical appliances for handling freight rapidly to and from drays and in sheds should materially reduce congestion.

As to the question of two levels it seemed entirely practical, and the economy of space was of sufficient importance fully to justify it, but the best division of work between the two levels might be an open question. Railway cars, drays, and passenger traffic, both foot and carriage, must be considered. A separation of grades was desirable and with two grades for three classes of traffic it seemed better to combine dray and passenger traffic on one level than to combine either one with railway traffic. If passenger traffic alone was to pass over the second floor the force of Mr. Donnelly's argument that only a light structure would be required could be conceded, but this arrangement would not accomplish the desired result, as there would be railway cars, street trucks, and foot passengers all on grade, for it was not possible to exclude foot passengers where trucks were allowed. There were several advantages in elevating the railway tracks. Grade crossings would be eliminated. With suitable freight handling facilities, the freight could be unloaded from steamer to the second floor of the pier shed fully as cheaply as it could be unloaded to the first floor. If the chain of local freight stations and the distributing railway were installed most of the freight would come to and leave the pier by rail and would be handled on the second floor level without interruption or interference by truck and passenger traffic which would have exclusive use of the grade level. It had become the established practice where traffic demanded separation grades to put steam railways either overhead or underground, reserving the street level for truck and passenger traffic, and it was a question if this practice could be reversed in the case of the New York waterfront.

ELIAS CAHN [1] agreed with Mr. Sawyer in regard to the relative

[1] Dock Department, Pier A, North River, New York.

cost of the railroad tracks on the grade and an upper level. If the street was to be 250 ft. wide, as it would have to be to provide for wagon and vehicular traffic as well as foot passengers, at least 50 ft. of this roadway would be needed for railway trains, which would make the cost very great; if the cost of the ramps leading up from the street to the elevated structure were added to this, the expense would be even greater. The ramps would require about a 5 per cent grade, necessitating a length of about 500 ft. Immediate adoption of this plan would be impossible, as many of the piers had only one floor, and the railroad companies would not adopt this system immediately. In the meantime the city would suffer damages.

The provision of an elevated roadway meant practically raising the street, and all the buildings alongside the street would suffer damages in consequence of the changes required to adapt them to the new scheme. If the former were adopted, every one of the single-story piers would have to be changed to a two-story structure, and all the houses alongside the street would have to be changed accordingly. The property in the street where the ramp was located would likewise suffer damages, and the cost would be absolutely prohibitive. An elevated freight railroad therefore appeared preferable to an elevated street.

Geo. A. Orrok presented some figures for the cost of handling coal on a pier which was properly designed for the purpose. Some twenty years ago when he first commenced to study the coal-handling business, it was thought very satisfactory if coal could be removed from a ship for anywhere from 25 to 30 cents per ton. When this cost was reduced to 14 cents a ton it was thought remarkably low indeed; it was only a few years since it reached as low as 7 cents a ton. Today, coal in bulk, both at the big power stations and at the big receiving points, was being taken out of ships and barges at an expense not exceeding 2 cents a ton where trimming could be left out of the question. Most of the ships used for the transporting of coal were self-trimming ships.

Mr. Orrok did not think, however, that package freight could be handled from vessels by machinery. If there were, as very frequently happened in a steamer, 4000 to 5000 packages of freight of all sizes, from a few pounds up to 15 tons in weight, each of the packages probably addressed to different persons

scattered over at least three-quarters of the United States, they could not be put in the same freight car, but had to be separated on the pier. Under these conditions it looked as if the present way of handling it was about the best way. Handling packages by machinery took a good deal of time and money: the men had to be paid to do the work, and at the same time the machinery had to be kept up. A man with a two-wheel truck could do the work just as well, in most cases at less cost.

Mr. Harding replied that it did not appear to be economical when the weight of the package was small, say 25 lb., but the average of the consignments was very much greater. On one pier in New York City the weight of the average consignment that came across the bulkhead was about 750 lb., while at another in Providence, it was 1000 lb., and on the steamships it was about 1200 lb., varying according to whether it was in the coastwise service or a trans-Atlantic liner.

W. C. Brinton [1] said that practically all the equipment and devices described by Messrs. Harding and Donnelly had to be installed at the time a pier shed was built. It was not usually feasible to place overhead equipment in the type of pier sheds or warehouses existing today. The head room in most of them was not sufficient to permit the economical operation of an overhead system. Though it might be possible physically to install an overhead system in existing types, the room available between the bottom of the carriers and the floor would be so small that there would not be sufficient height for tiering goods.

The overhead systems of telpherage and transferage might possibly be developed in the future so that it would be advantageous to install these systems for certain classes of work when entirely new piers or warehouses were being built. Looking ahead a few years, the overhead system would first become a definite success on specially constructed piers which handled only cargos of a single commodity or cargos containing but a few different lots and thus requiring but little sorting.

He stated that there was in this country today an investment of several billion dollars in piers on which the overhead system could not be applied in such a manner as would give a fair financial return on the investment. Pier owners could not afford to

[1] Bush Terminal Company, Brooklyn, N. Y.

tear down their old pier sheds and build new ones in order to get the head room required by any transferage system.

Storage battery trucks were the most feasible means for immediate improvement with existing piers and warehouses. There were a great many plants in which storage battery trucks could make a direct money saving as compared with the cost of hand trucking. One of the chief advantages of the storage battery truck consisted in its ability to do the same work in less time than was required by hand trucking. The freight handling capacity of existing piers could be increased by the electric truck, and ships would not need to be detained in port as long a time as was now required.

Weather and other conditions beyond human control made it impossible to have freight steamers arrive on any regular schedule. The result followed that the work on most piers was either a feast or a famine. For rapidly fluctuating volumes of work there was a great advantage in having machinery which was completely self-contained and which could be instantly moved from pier to pier wherever the work might be.

He thought that engineers had not yet fully developed the possibilities of electric machinery driven from flexible cable plugged in at any convenient socket on piers completely wired with power circuits. Storage battery cranes and dock trucks were but in their infancy. Considering the great investment required for new and higher pier sheds, and the investment in overhead trackage which on the average pier must occasionally remain entirely idle, the most promising means for immediate improvement lay in machinery operated on the floor level and driven from flexible cable or from storage batteries.

BOSTON MEETINGS

At the meeting of the Society in Boston on February 25, the principal paper, Some Thermal Properties of Concrete, was presented by Prof. C. L. Norton, Mem.Am.Soc.M.E. This was followed by a brief paper on Experience with Concrete in Fires, by G. E. Fisher, engineer of the Arkwright Mutual Fire Insurance Companies. On March 25 Frank W. Reynolds, Mem.Am.Soc.M.E., presented the main paper of the meeting, The Modern Cotton Mill. This was followed by short papers on Lighting of Mills, by Albert Pearson, Mem.Am.Soc.M.E., and Air Conditioning for Textile Mills, by Frederick W. Parks, president of the G. M. Parks Company, Fitchburg, Mass.

Abstracts of the papers, together with the discussion presented at each meeting, are given herewith. The complete reports are on file in the rooms of the Society.

SOME THERMAL PROPERTIES OF CONCRETE

By Charles L. Norton, Boston, Mass.

Member of the Society

Since December 1907 a series of experiments has been carried on in the laboratory of heat measurements of the Massachusetts Institute of Technology, having for its object the study of those physical properties of portland cement concrete which affect its value as a fire resistant material. While these researches are not complete, it is perhaps of interest at this time to discuss some of the results obtained.

It was proposed at the outset to make a study of the various physical properties of portland cement concrete over as wide a range of temperatures as possible, and among the properties were the following:

a Coefficient of linear expansion

The American Society of Mechanical Engineers, 29 West 39th Street, New York.

b Diminution of mechanical strength after heating
c Specific heat
d Coefficient of thermal conductivity

A comparison with other materials was also planned.

COEFFICIENT OF LINEAR EXPANSION

The measurements of the coefficient of linear expansion are now practically completed. The method adopted for the measurements of elongation caused by heating was the common so-called telescope method. The specimens in the shape of 6-in. or 10-in. cubes were slowly heated in a double gas muffle or an electric resistance furnace. The temperature of the furnace and of a number of points in the concrete was taken by means of platinum-rhodium couples. Near the furnace were mounted two telescopes, which could be sighted through holes in the furnace wall upon reference points on the surface of the block. At low temperatures an arc light and system of mirrors were used to furnish adequate illumination. One of the telescopes was provided with a micrometer eye-piece by means of which a movement of the reference mark of 0.0001 in. could be measured.

The values obtained at low temperatures agree very well with the commonly accepted value of 0.0000055 for the elongation per unit of length per deg. fahr. Apparently this value increases slightly up to 575 deg. fahr. Above this point the coefficient becomes smaller; at 1,500 deg. fahr. the coefficient becomes zero, and above this point, slightly negative.

Table 1 gives the average values for a large number of specimens:

TABLE 1 AVERAGE VALUE OF SPECIMENS

Temperature, Deg. Fahr.	β in the Expression $l_t = l_o\ (1 + \beta t)$
72 to 360	0.0000045 to 0.000060
72 to 750	0.0000050 to 0.000060
72 to 1090	0.0000045 to 0.000050
72 to 1600	0.0000035 to 0.000042

The blocks which had been heated to 1,500 deg. did not return to their original dimension on cooling, their permanent elongation being about 75 per cent of their maximum elongation. There was no sensible permanent elongation resulting from a second heating.

All of the specimens tested for expansion were of stone concrete of the proportions 1: 2: 5. The stone was clean, the sand sharp, the cement of good quality, and every precaution was

taken to secure a concrete of the first order. The specimens weighed on the average 150 lb. per cu. ft. A considerable number of tests demonstrated that the dimension which these small cubes took during a rise in temperature was dependent upon the temperature of the outside rather than the average temperature of the block.

The variation of this coefficient with the temperature is such as to make the difference between it and the coefficient for steel considerable at high temperatures. As has been well understood, the similarity of the coefficient is helpful in preserving the integrity of reinforced concrete structures at ordinary temperatures, but the divergence of the two coefficients at higher temperatures is not a serious matter in the reinforced structure when exposed to fire, since the metal reinforcement and the concrete surface are rarely at the same temperature.

There is a marked expansion increase up to about 700 deg. fahr. followed by a slower rate, and at about 1500 deg. fahr. by marked shrinkage.

COMPARISON WITH CLAY BRICK AND SILICA BRICK

	Clay Brick	Silica Brick
Temperature Range, Deg. Fahr.	Coefficient of Expansion (β)	
0 to 900	0.0000038	0.000012
0 to 1600	0.0000031	0.000008
0 to 1900	0.0000023	0.000007

Some bricks and all concrete are liable to a permanent set of about 75 per cent of their total elongation on heating to 1500 deg. fahr.

DIMINUTION OF MECHANICAL STRENGTH AFTER HEATING

In order to study the effect of high temperatures upon the compressive strength of concrete several scores of 6-in. and 8-in. cubes were made and allowed to set for 90 days or slightly longer. These blocks were heated at different temperatures in a gas furnace similar to that used for the expansion experiments, for different lengths of time at various periods from the 90 days up to five years.

The cubes which were not heated showed an average compressive strength of 2700 lb. per sq. in. when 90 days old; at the end of five years the compressive strength of the blocks had risen to an average value of 4278 lb. per sq. in. When aged for 90 days *in a damp place*, exposed to fire at 900 deg. fahr. for two hours,

the compressive strength fell to 2200 lb., or a loss of 15 per cent. Blocks five years old, dry, exposed to fire at 1700 deg. fahr. for two hours, gave values of 1500 to 1900 lb. per sq. in., a loss of 50 per cent to 65 per cent.

The loss was much more marked in the case of the 6-in. than the 8-in. cubes. It is evident that the small cubes give far too great loss in strength on heating. Some cubes allowed to stand lost much by slacking; this action has been noted by Professor Woolson in earlier tests. It should be noted also that there was a considerably greater deformation under load of the heated blocks than of those not heated.

A large number of small beams were next made, some with and some without reinforcement; most of these were either 6 in. by 6 in. by 48 in. or 8 in. by 8 in. by 48 in. The specimens which were reinforced contained four ½-in. round steel rods situated near the corners equidistant from the two faces of the beam. In some the distance from the reinforcement to the face of the beam was 1 in. and in others 1½ in. A few beams had a 2-in. protection to the reinforcement.

Three beams for example, each 6 in. by 6 in. by 48 in., in which the reinforcing rods were 1 in. from the face of the beams, were broken by center load, the first beam not having been heated at all, the second heated for one hour in a fire that fused the surface of the concrete, and the third being similarly heated for two hours. The beam which was not heated broke under a load of 5700 lb., the second, heated for one hour, broke at 2750 lb., while the third, heated for two hours, broke at 1950 lb. This is a most remarkable showing under severe conditions. It should be borne in mind that these small beams were so slow in cooling down that they showed the effect of heating much longer than the time mentioned, say 24 hours. The flames, moreover, surrounded the beams on all sides. In tests at three and five year ages, the temperature was between 1600 deg. and 1700 deg. fahr.; the 8 in. by 8 in. by 48 in. reinforced beams broke at 14,200 lb. when not heated, but at 4920 lb. when heated. Smaller beams 6 in. by 6 in. by 48 in., not reinforced, broke at 1300 lb. when not heated, at less than 100 lb. heated.

As a result of these tests upon the beams, it was evident that the failure of the specimens was in every case due to the rods pulling through the concrete. This is wholly a matter of insufficient anchorage, and these short beams are therefore not very

helpful in giving information concerning the behavior of full-sized beams in buildings, and except as they give relative information concerning different mixtures, they are of very little value. The small cross-section of these beams tends to make the fire exposure abnormally high. It should be noted that all of the non-reinforced beams broke in handling, which suggests the severity of the tests as compared with the experience of actual conflagrations.

A series of similar beams was next made up of cinder concrete, the proportions of the mixture being 1 : 2 : 5. A portion of these were mixed with clean cinders, which showed upon analysis but little carbon; a second part was mixed with cinders to which 10 per cent of fine bituminous coal had been added and the other beams were mixed with cinder, to which had been added 25 per cent of fine coal. The 25 per cent mixture can be disposed of in a word—when once thoroughly heated it burned until it fell to pieces. With the 10 per cent mixture, however, no such action occurred; there was no indication that the concrete would support its own combustion even for a short time. It was apparent, however, that the 10 per cent mixture was not so good a fire-resistive material as that which contained no added carbon. From the few specimens containing less than 10 per cent which have been examined up to the present, it seems probable that the safe limit is close to 5 per cent. More information is now being secured on this point by the use of larger beams.

SPECIFIC HEAT

The study of the specific heat of concrete was made by the ordinary calorimeter method, the " method of mixtures " of Regnault. Specimens of the concrete, usually fragments of the larger test pieces, were heated slowly in an electric resistance furnace to the desired temperature and then plunged into the calorimeter. The weight of the water and its rise in temperature give the amount of heat given off by the body in cooling. Extraordinary precautions were taken in getting the exact average temperature of the specimen in the furnace, and to insure its rapid transfer to the calorimeter. In most of the experiments a double calorimeter was used so that the specimen did not come in contact with the water of the calorimeter, so that any evolution of heat by hydration of the cement was avoided. Tables 2 and 3 give the specific heat of concrete and of other materials.

TABLE 2 SPECIFIC HEAT

Temperature, Deg. Fahr.	Stone Concrete 1—2—5	Stone Concrete 1—2—4	Cinder Concrete 1—2—4
72 to 212	0.156	0.154	.....
72 to 372	0.192	0.190	0.180
72 to 1172	0.201	0.210	0.206
72 to 1472	0.219	0.214	0.218

TABLE 3 SPECIFIC HEAT OF OTHER MATERIALS

Material	Temperature	Specific Heat
Stone Concrete	72 to 500	0.210
Stone Concrete	72 to 800	0.204
Stone Concrete	72 to 212	0.180
Cinder Concrete	72 to 212	0.156
Red Brick	72 to 212	0.214
Red Brick	72 to 500	0.192
Red Brick	72 to 1100	0.200
Quartz	400 to 1200	0.308
		0.305
		0.279
Cement	room temperature	0.271
		0.186
Sand		0.191
Trap		0.201
	?	0.258
		0.270
Sandstone	?	0.220
Dolomites		0.222
Slag		0.169
Granite	?	0.173
		0.196
		0.200

COEFFICIENT OF THERMAL CONDUCTIVITY

The measurements of thermal conductivity were made by a number of methods and have taken far more time and energy than all the others put together. The thermal conductivity is that property which determines how rapidly heat will travel through a substance and how rapidly therefore objects beyond will be heated by transmission. The conductivity becomes of prime importance in all questions of protection of the metal in reinforced concrete buildings. There is a limited amount of data to be found relative to this important property of any of the

common materials of engineering and such data as are to be found are not concordant. As to the conductivity of concrete or its variation with temperature and with composition, practically nothing has been known.

The methods adopted for the measurements will be here described in outline only. The formula showing the relation of the temperature upon the two sides of a plate to the amount of heat which would flow through it is as follows:

$$Q = \frac{K(t_1 - t_2)\,sA}{d}$$

$$\text{or}\quad K = \frac{Qd}{(t_1 - t_2)As}$$

where

K = the coefficient of thermal conductivity dependent upon the nature of the material and its temperature
Q = the quantity of heat flowing through the plate in the area measured
A = the area
t_1 = the temperature of the hotter side of the plate
t_2 = the temperature of the cooler side of the plate
d = the thickness of the plate
s = time during which Q units flow through the area A.

The formula will be seen to be merely an expression of the following relations, that the flow of heat is proportional to the area, to the temperature and to the time, and that it is inversely proportional to the thickness.

After spending many months in attempting to develop other methods, the electrical method used by the writer for the past 15 years in studying the flow of heat through steam pipe coverings was adopted. The value Q of the heat flowing was determined by supplying the heat by means of the heating of a conductor carrying a current of electricity; by measuring the electrical energy supplied the quantity of heat developed may be known with great precision. Further, if this heat is passed through the plate under test and into a calorimeter on the far side, a check upon the value of Q may be had. For the determination of the temperature difference, thermal couples, resistance thermometers, and mercury thermometers were used, but thermal junctions made of thin strips of copper and nickel, or of platinum and platinum-rhodium, were generally found most serviceable.

The apparatus used for the lower temperatures consisted of a thin, electrically-heated plate, to the two sides and edges of which concrete could be applied. Outside of the concrete there were then placed heavy copper or brass plates which could be kept at a constant temperature by an internal circulation of water. Thermal junctions were placed at several points on each surface and in the body of each concrete plate. The electrical input was measured by calibrated Weston instruments, and calibrated thermal junctions gave the value of the temperature difference to the nearest one-one hundredth of a degree. For the thickness, numerous measurements were made with a pair of flat-nosed calipers and averaged. It was necessary to keep this apparatus running for several days before it could be balanced, that is, before the rate of flow of heat outward through the plates became constant and equal to the electrical input.

Later, in order to make tests on plates as thick as some of the walls in common use, another method was adopted. Cubical boxes 36 in. in outside dimension were built with walls of several thicknesses. Inside the boxes were placed electric heaters which served to raise the inside surface to a temperature above that of the surroundings and a small fan served to keep the air in the box stirred to insure uniformity of temperature throughout. The boxes were tightly sealed. The power supplied to both heater and fan was measured as before. Mercury thermometers and thermal junctions, as well as a Callender recording resistance thermometer, were used to measure the difference in the temperatures inside and outside of the box.

Data have been secured on scores of specimens and they are practically identical with the results obtained by the plate tester. It must be borne in mind that the thermal conductivity is based upon the difference in temperature at some two points in the material itself and not the difference in the temperature of the air on the two sides of the specimen. If, for instance, a 6-in. wall of solid stone concrete separates two spaces whose temperatures are 40 deg. fahr. apart, the surface temperatures of the concrete will be much nearer one another than 40 deg. fahr. There is a drop in temperature in passing through the wall which is dependent upon the thermal conductivity and upon the quantity of heat passing through. There is a drop in temperature at the surface which is dependent on a rather complex set of relations between the temperature and nature of the surface

and the surroundings and the adjacent air. For many materials the amount of heat lost from a surface for small differences in temperature not over 20 deg. fahr. is between 16 and 18 B.t.u. per sq. ft. per 24 hours for 1 deg. difference between the surface and the average temperature of the surroundings. More than one-half of this is a loss by radiation in accordance with the Stephan-Boltzman law.

$$\text{Energy} = \text{Constant } (T^4 - T^4_0)$$

$$W = 5.7\, E \left[\left(\frac{T}{1000}\right)^4 - \left(\frac{T_0}{1000}\right)^4\right]$$

where

W = watts

T = absolute temperature of surface

T_0 = absolute temperature of surroundings

E = about 0.6 to 0.7 (always less than 1)

For the high temperatures a modification of the entire process was found necessary. The concrete to be tested was cast in the form of a cylinder on the outer surface of and concentric with a steel bar which could be heated to a high temperature by the passage of a heavy current. Outside of the cylinder of concrete was applied a closely fitting "continuous" calorimeter. The temperatures of the bar and of the calorimeter were measured by thermal junctions, and the amount of water and its rise in temperature gave the value of Q. In order to guard against the uncertainty of the temperature at the ends of the bar, the calorimeter was made so as to enclose only about one-half the length of the bar, the rest being covered by guard rings similar to the calorimeter, but without provision for the measurement of the quantity of water.

The heating of the bars required a considerable amount of special apparatus, since it was necessary to provide a current of upwards of 2000 amperes for the high temperatures, and to be able to vary its amount to any desired value below that point. For this purpose there were installed three 15-kw. transformers connected on the primary side with a three-phase 2300-volt circuit. By means of divided secondaries and a rather elaborate arrangement of switches, the secondary voltage could be varied from 190 volts down to 55 volts. This secondary voltage was applied to the primary of a second step-down transformer, whose secondary was divided into 20 coils. By means of a switchboard the entire output of the transformer could be had at almost any

desired low voltage. This enabled us to heat bars insulated by materials of different composition and of different thicknesses to any desired temperature up to 2800 deg. fahr. With this arrangement both the steel and the concrete can be easily melted.

The results obtained are given in Table 4. It is to be regretted that there is no uniformity of practice as to the units to be adopted in reporting the measure of effectiveness of insulators. While the physicist renders his report in calories per square centimeter, per centimeter thickness, per one degree centigrade per second, the steam engineer confines his observations to B.t.u. per hour, per square foot, per inch of thickness, per one degree fahrenheit, and the refrigerating engineer reports on the basis of a 24-hour time unit. The writer has even seen a report in

TABLE 4 COEFFICIENT OF THERMAL CONDUCTIVITY OF CONCRETE

Temperature of Hot Side of Plate		Mixture	Coefficient, Cal. per 1° C. per sq. cm. per cm. per sec.	Coefficient, B.t.u. per 1° F. per sq. ft. per in. thick per 24 hours
Deg. Cent.	Deg. Fahr.			
35	95	Stone 1—2—5	0.00216	150
50	122	Stone 1—2—4 not tamped	0.00110 to .00160	76. to 114.
50	122	Cinder 1—2—4	0.00081	56.
200	392	Stone 1—2—4	0.0021	146.
400	752	Stone 1—2—4	0.0022	153.
500	932	Stone 1—2—4	0.0023	160.
1000	1832	Stone 1—2—4	0.0027	188.
1100	2012	Stone 1—2—4	0.0029	202.

terms of hogsheads of water raised to the boiling point, time not stated. A brief comparison of these values with those for other materials may be interesting.

The specific heat of concrete is slightly less than that of either red brick or fire brick, hence the amount of heat needed to raise the temperature of a pound of brick is about 10 per cent more than for a pound of concrete. But the density of concrete is enough greater than that of brick to raise the heat capacity of a cubic foot of concrete above that of brick. The difference is not large, however.

It seems clear that for a time after the beginning of exposure to fire, the concrete and its reinforcement will expand at much the same rate, but that the further expansion of the surface will

not proceed at so rapid a rate. This will tend to reduce the stresses which the expansion of the heated surface would otherwise set up in the cooler interior. It is perhaps because of the failure of the concrete to return to its original dimensions that the small amount of surface cracking found after a fire is due.

The experiments made with coal and cinder mixtures indicate the necessity of added care in the selection of cinders for this purpose.

Table 4 of thermal conductivities gives data as to the rate at which heat will travel through concrete. It is interesting to note the great difference between the tamped and the untamped con-

TABLE 5 THERMAL CONDUCTIVITIES

Material	B.t.u. per 24 Hours per 1 Deg. Fahr. Sq. Ft. per 1 In. Thick
Agglomerated Cork	6.4 to 9.0
Linings or Quilts of Hair and Flax	10.0 to 18.0
Pine	13.0
Oak	26.0
Spruce	14.0 to 18.0
Magnesia	10.0
Asbestos Sponge	8.0

cretes made from stone. The one was as porous as possible, and the other as dense. One transmits nearly twice as much heat as the other. The cinder concrete, as is commonly believed, is much better as a heat insulator than the stone concrete, being nearly three times as effective as the denser stone concrete in retarding the flow of heat. It may be interesting to call attention to the heat insulation afforded by other materials. The best of the commercial articles commonly used for this purpose is compressed cork, which is nearly 25 times as effective as stone concrete. Steel, on the other hand, transmits heat from 75 to 100 times as fast as the densest of the stone concrete.

EXPERIENCE WITH CONCRETE IN FIRES

By G. E. Fisher,[1] Boston, Mass.

Non-Member

The fact that a building is of concrete construction seems to carry with it the idea that it is fireproof, regardless of occupancy. This word fireproof is a misnomer when applied to any kind of a building and it is gradually being displaced by the word fire-resistive, which includes not only concrete construction, but also the type now so common involving steel frame work protected with tile, concrete or brick. No building is absolutely fire-resistive, for the resistance offered to fire is one of degree only, and if the heat be sufficiently intense and prolonged, nothing can resist it.

At high temperatures the surface of concrete is easily injured and spalls badly when water is thrown on it, and both actual fires and experiments have proved that where these temperatures run from 1400 deg. to 1900 deg. fahr. the surface of the concrete may be injured to a depth of ½ in. to ¾ in., or even 1 in., but the body of the concrete is not affected. Excellent heat insulation is afforded by concrete, but to obtain the best results a sufficient thickness must be applied, depending largely upon the occupancy of the building under consideration. Experience has shown that 2 in. of concrete will protect an I-beam with good assurance of safety. Obviously a building having combustible occupancy should have a heavier protection of concrete over reinforcing members than one having noncombustible occupancy.

The best fire-resistive materials are usually considered to be first-class portland cement with quartz sand and broken trap rock. Limestone aggregate will not stand the heat so well as trap and the particles of gravel are more easily loosened by extreme heat. Cinders make a good aggregate for fire resistance, but the concrete made with them is not so strong as the rock concrete and cannot be used where high compressive values are necessary. Considered from an insurance point of view, cinder concrete is not so desirable as that made of trap rock on account of the porous quality of cinders; the insurance companies have learned that with cinder concrete they are called upon to pay losses on account

[1] Engineer, Arkwright Mutual Fire Insurance Company.

of damage from water used at times of fire, which percolates through the small interstices of the cinders, which the cement mixture cannot reach, to the floors below.

At the Baltimore fire there were only 27 buildings of fire-resistive construction in the whole burned area, these buildings ranging from 1 to 14 stories in height. Of this number that of the International Trust Company of Maryland had floors of reinforced concrete, and that of the United States Fidelity and Guarantee Company had floors and roof of reinforced concrete. In both cases the floors and roof passed through the fire very well and, except for slight cracking and settling in a few places, were practically uninjured. The conclusions reached regarding concrete by the Baltimore committee that investigated the fire were that, while concrete floor-arch construction was used in only a few buildings exposed to this conflagration, as far as tested the concrete stood in good shape.

At the San Francisco conflagration every type of construction was represented and the ruins afforded a most excellent opportunity for comparative study, although the information obtained was incomplete, as materials were not subjected to action of hose streams on account of failure of water supply. The Academy of Sciences building of concrete construction, six stories high, was completely destroyed, but a six-story annex had brick walls, reinforced concrete floors and concrete-filled cast-iron columns which proved an interesting feature after the fire. Owing to the unequal expansion of the cast iron and the concrete, the cast iron failed by bulging from the heat and cracking on cooling. In the basement where the fire was fairly hot the 1 in. thickness of concrete which covered the reinforcing bars proved insufficient; the heat expanded the bars, which pushed off the concrete layer and left the rods exposed.

A building for the Bakins Warehouse & Storage Company was in process of construction, being built largely of reinforced concrete, and at the time of the earthquake, two of the six floors were completed. The walls were of brick laid in lime mortar and the floors and columns of reinforced concrete. The walls were badly cracked by the earthquake but the reinforced concrete was not injured. Considerable furniture stored in this building was burned, but beyond a slight blistering of the under surface of the concrete floor, no damage resulted. In the Pacific States Telephone and Telegraph Company's building the heat produced

by the burning of the insulation on wire and other supplies was intense and protracted. The reinforced concrete beams of the roof were weakened by heat and had to be replaced, but the concrete in general stood the trial exceedingly well considering the very high temperature. The concrete floors and column protection were not damaged in the least.

In this fire, concrete, especially reinforced concrete, proved more satisfactory than any other material, though concrete in San Francisco was of very poor quality; a flimsy material stiffened with light metal had been passed as reinforced concrete. Cinder concrete was used extensively but was of a very inferior grade; much of it was high in sulphides which had a destructive effect on the embedded material, especially where slight cracks permitted air and moisture to come in contact with these sulphides and metal. It is further stated that most of the failures were the result of bad design, poor workmanship and poor materials. If, therefore, reinforced concrete of this quality could give such satisfactory results under the extreme conditions of the San Francisco earthquake and fire, it is evident that much greater satisfaction could have been given by first-class materials.

It is particularly noticeable in the study of conditions at San Francisco that after the earthquake the large number of buildings which failed to stand was due to the early collapse of protected steel frames. The failure of the protection to withstand the earthquake shock exposed the steel work to the fire and the fire damage to these fire-resistive buildings was estimated as high as 60 per cent.

Reports from fires in other sections of the country furnish further interesting information. At the Dayton Motor Car Works and Huyler's building in New York City, the fires were so hot as to destroy all inflammable material and yet the buildings themselves were damaged only to a very slight extent; the burned-out floors were occupied within two days after each fire. Another example is that of a two-story building of reinforced concrete construction used for drying purposes; this building was considerably exposed by frame buildings adjacent to it, and at the time the frame buildings burned, one part of the concrete structure was subjected to severe heat from a burning boiler house and grease-extracting building. The heat melted the wire glass in the windows and burned up all combustible materials in the finish of the building, but the damage to the concrete walls and

floors was very slight. Still another case is that of a reinforced concrete building, four stories in height, in which the heat from a fire was so intense that it fused a piece of cast iron into a shapeless mass, but the only damage resulting was that in several places throughout the building the concrete was split off to a depth of 1/4 in. to 1 in.

In the case of an extremely hot fire in a pulp and paper mill, the principal effect of the heat observed was to expand the floor and to cause a movement of the columns. On the morning after the fire, while the concrete was still hot, the end wall of the mill was noticeably out of plumb; later on, as the wall cooled, it drew back to the perpendicular. There were several minor breaks in the concrete and some parts of it were spalled off to a depth of about 2 in. Where the concrete was rich in mortar there was less damage than where it was stony, the mortar acting as a protection to the aggregrate. Where the fire was hottest the concrete was softened for an average of 1 in. so that it could easily be knocked off with an ordinary hammer.

It is one of the requirements of our Mutual fire insurance companies that sprinklers be installed in all manufacturing buildings having combustible material either in their construction or occupancy, and in all fire-resistive buildings having combustible occupancy. A great many buildings throughout the eastern and middle states are insured which are of reinforced concrete construction, but with the exception of a few office buildings or where the building has a noncombustible occupancy, they all have sprinklers. The result is that a fire starting in any part of the building is quickly controlled by the sprinklers with but little if any damage. This combination of good construction and good sprinkler protection is one which will keep fire losses at a minimum.

Some interesting information was furnished by a fire in one of these fire-resistive buildings, which did not have sprinklers, by a fire that destroyed the contents. The building, which was occupied for general office purposes and had the usual fittings and trimmings of a modern office, was three stories in height with 17-in. walls of brick and had tile and reinforced concrete floors and roof, supported by two rows of reinforced concrete posts and beams on all floors. On account of its superior construction and safe occupancy, sprinklers were thought not absolutely necessary. The intense heat generated by the burning of

the hardwood overlay on the floors and the hardwood office fittings affected the brick walls, the concrete windowsills, and the concrete belt extending around the building at the third floor level. It is thought that most of the spalling of the concrete work was due to cold water from hose streams on the hot material. The structural strength of the concrete columns appeared to be very much reduced by the fire, and to determine whether it was necessary to replace them and the beams damaged in the fire, shores were placed under a third-floor beam ½ in. clear at the top, to take the weight, should it settle when loaded. Careful measurements were taken of the distance between the underside of beam and top of floor below. A load of 16 tons of iron was placed on the third floor over the beams to be tested, and the deflection was 7/64 in. in the center of beam. This occurred at once when the load was applied, and did not increase while the test continued, namely 3 hours. For comparison, the same load was then placed over an uninjured beam elsewhere, and the same measurements taken, showing a deflection of 6/64 in. or practically the same as found in the damaged beam. No settling could be detected around any of the damaged posts when the load was applied.

In repairing this building a cement mixture was made and the beams and columns built out with it wherever spalling had taken place. It is doubtful if a person examining the building today could detect any traces of this fire. It has been equipped with automatic sprinklers, and as a further precaution against another fire the new office furniture is all metal so far as could be obtained. From the writer's own experience, however, he would not consider this last precaution necessary, for in a building well protected with sprinklers the chance of a fire getting outside the area of two or three sprinklers is remote.

DISCUSSION

A. S. Kellogg, referring to the applicability of the results of the tests to heating and ventilating work, said that thin dense concretes seemed to be about as bad surfaces for the transmission of heat as could be found, especially in the first two or three years after the construction of the building.

C. L. Norton replied that the heat transmission value of material put on in thin sheets was a matter which must be proved with the interior heating facility arrangement described in his

paper. He did not know exactly the proper treatments to apply. In places the concrete had to be used in thin sheets on account of cost, and in comparison with other thin materials, as glass, hair-felt, etc., the heat transmission was enormous. In reply to questions as to what was the heat transmission through a wall 4 in. to 6 in. thick as compared with glass, he said that he thought the loss through a concrete slab could not be equal to the loss through a glass window, which would not dispose of heat on its far side and would not receive heat on its near side. The glass might still be much thinner and prevent flow of heat through it. In testing two refrigerators, one of a dull wood and the other of a less effective insulating material coated with enamel of a bright shiny nature, through the latter the heat entered less quickly than through the former, which was noticeable in the melting of the ice.

In answer to a question regarding his experience with concrete composed partly of granite, Professor Norton said he had a number of specimens of concrete made from typical eastern Massachusetts granite obtained somewhere near Lowell. It stood the fire very well, probably because there were no larger pieces in it than would go through a 1½-in. ring. It spalled on the outside for a depth of about ¼ in., but he considered it as good as a piece of cinder concrete, and would not hesitate to use it in preference to most of the rough stone, which when heated to a high degree split and cracked.

A. L. Williston stated that Professor Norton's experiments were conducted mostly at high temperatures while the question that came up in heating and ventilating work was on temperatures below 212 deg. fahr. At the higher temperatures it was found that the conductivity increased as the temperature increased, also as compared with age, moisture, etc. He wanted to know if the presence of water would not make it a poorer conductor or poorer insulator. Professor Norton replied that he could not answer that question. A year ago he would have stated that he knew, but six months ago an anxious inventor of a porous material came to the laboratory and insisted that his material was just as good wet as dry. This statement was not altogether true, but it was found after numerous tests that it could not be predicted what the effect would be on porous material. In regard to what difference the age made, moisture hung below 212 deg. fahr. with the green specimen. A specimen heated for days

and days at 105 deg. cent. (221 deg. fahr.) was found still to lose weight and it took something like ten days or two weeks to get all the moisture out.

In reply to a question as to experience with concrete as more hygroscopic than other forms of materials, he stated that it was certainly not noticeably different from terra cotta brick.

Mr. Williston inquired if concrete would reabsorb moisture after it was allowed to stand in the ordinary room, if in seasoning it or heating it all the moisture had been driven out, which had consumed considerable time; also if it would reabsorb more than brickwork. Professor Norton answered that he did not know what brickwork would do, but concrete would reabsorb slowly for a long time, back to its constant; he had taken specimens and dried them out thoroughly and they began to pick up moisture within ½ hour and then reabsorb slowly for 20 or 30 days.

SOME OF THE PROBLEMS ENCOUNTERED IN THE DESIGN, CONSTRUCTION AND EQUIPMENT OF THE MODERN COTTON MILL

By Frank W. Reynolds, Boston, Mass.

Member of the Society

Among the problems entering into the design of the cotton mill, the most important are the selection of the proper site, the proper arrangement of the buildings to suit the site, the proper arrangement of the buildings for the best placing of the machinery and routing of material, the proper design of the buildings for strength, rigidity and natural lighting, the proper arrangement of power plant and the arrangements of power distribution, artificial lighting, heating and air conditioning in the work rooms and fire protection. Also the toilet rooms and other sanitary features must be considered. In commencing the study of a new mill plant the usual order of procedure is to organize the machinery equipment for the goods to be manufactured. For a given product either of yarn or cloth, the machinery equipment is calculated and tabulated on standard forms, which determine the numbers of machines in each process with the speeds and production of each machine. With this information as a basis the next step is to arrange the given number of machines in proper relation to each other so that the routing of stock in process of manufacture is accomplished without interference or unnecessary travel and so that future extension of the plant may be made in an acceptable manner.

Naturally, the next considerations are the proper width and height for the buildings, the spacing of columns to be adopted, the height of story, whether the spinning department and weaving department shall be in one and the same building or in separate buildings, whether or not mechanical or electrical transmission shall be used, and many other items which affect the arrangement of the projected mill.

This study of the arrangement of machinery and buildings is one of the most necessary and interesting parts of the labor of designing a plant and upon a proper solution depends in great measure the success or failure of the plant from an economical operating standpoint. Much unnecessary labor in the mill is often expended because of the poor arrangements of buildings forming parts or the whole of a group and the equally poor arrangement of the machinery within the buildings. It must be realized that the least number of motions made and the shortest distances traveled in manufacturing operations are conditions to be sought and not deliberately neglected.

At this stage also the question of the site becomes predominant. It is something always to be reckoned with and sometimes contended. Shall the buildings be arranged to suit a given site and perhaps be poorly arranged, or shall the site be purchased to suit the best arrangement of buildings? Oftentimes the buildings must be arranged to suit the site and there is no alternative. This is particularly true of sites for new mills in cities or for extensions of existing mills either in cities or in the country.

It is assumed that the mill will be built in the country on a site where extensions may be made as they are required, where water exists, where spur tracks may enter the property and where there is so much land available at a reasonable price that the manufacturing buildings may be arranged as desired and the village planned to meet the requirements of healthful living. Also an expected product of 4000 lb. in 10 hours is assumed which determines the equipment at 65,000 spindles, with preparatory machinery and 1200 looms. There must be a storehouse for cotton, a picker house, a carding and spinning mill, a weave shed, a separate cloth hall, a storehouse for cloth, a separate repair shop, a waste house and a power plant arranged for the mechanical transmission of power to both mill and weave shed.

The width of the mill is determined by the arrangement and length of the mules which are placed across the mill to obtain the best light. This gives a width of 105 ft. for this building. The length of the mill is determined by the arrangement of carding and roving machinery giving a length of about 480 ft.

The number of stories is determined by the types of machinery used. It is necessary to have mule spinning for the filling yarn and ring spinning for the warp yarn. It is essential that these rooms should be separated if the mill can be so arranged. By

placing the carding department on the second floor, the mule spinning on the third floor and the ring spinning on the first floor, practically all of the space will be used to good advantage, and the machinery will be arranged to avoid cross-travel and unnecessary handling. The mill then should be three stories in height.

The width of weave shed is determined in this arrangement rather arbitrarily by limiting it to 155 ft., but arranging for overhead light. The length will be about 550 ft. While weaving mills are built 150 ft. wide without overhead light the results are never satisfactory from any standpoint, except possibly that of first cost when compared with the results obtained from a good weaving shed with overhead light. It has been proved in one plant at least that the cost of weaving has been decreased 50 per cent and the cost of artificial lighting 66 2/3 per cent in a new shed when compared with the costs of the work in a mill 70 ft. wide having light only from the side walls. Perhaps this is an extreme case, but it brings out the point that a weave shed is better than a weaving mill.

For mill buildings there are several forms of construction: (*a*) slow-burning mill construction with wood beams; (*b*) a variation of the first form using steel beams; (*c*) reinforced concrete construction. The first two forms have been and are used for nearly all mills. In the writer's opinion they have served their purpose and may be superseded by the third, which is a better form for practically every kind of mill or storehouse construction at nearly the same cost. It has many and decided advantages over other forms of construction which have been brought forward many times. Mills so built are rigid, they have the maximum amount of light areas in side walls, the cement floors may be smoothly finished and all wood floors eliminated, the interior walls, posts and ceilings may be painted immediately after completion, giving the best interior lighting effect; the stairways will be fireproof; all motors, shafting, piping and wiring may be as easily and more securely supported than from wooden surfaces and all machinery secured to floors without trouble; above all there will not be deflection in the floors between beams making the realignment of machinery so common in wooden mills a neglected feature. Furthermore, to answer an oft-repeated question, it should be said that belt holes in floors can be as readily arranged as in wooden floors. Therefore, in constructing the

modern mill reinforced concrete construction is to be adopted, which certainly is the most modern of all forms applicable to such structures.

For the mill building 105 ft. wide, a proper height of story would be 15 ft. from the top of one floor to the top of the next floor. The transverse bays would be 25 ft. on centers and the longitudinal bays would be 10 ft. 8 in. or 11 ft. on centers. In a building three stories high, with the usual form of mill construction, the floor beams would be 14 in. by 16 in. and columns not over 12 in. in diameter in the lowest story. In the reinforced concrete construction the same spacing of beams and columns will be adhered to; this has been demonstrated to be a more economical spacing than to omit every other column and run girders lengthwise of the building over each row of columns. In the three-story building of concrete construction the first-story columns would be 16 in. sq. The beams would be 12 in. wide and 19 in. deep from the bottom of the floor slab. The floor slab would be 6 in. in thickness and the top would be finished with a granolithic surface eliminating all wooden floors. The wall columns would be 12 in. by 16 in. and all of the space between these columns would be devoted to windows. The resulting construction will be absolutely rigid and secure with the maximum amount of area for light in the side walls and would be as nearly incombustible as a building can be.

Compare this construction with the ordinary mill construction and note the differences in rigidity of construction. In the ordinary mill are a series of brick piers for the outer walls connected above and below the window openings by spandrel walls. In each brick pier at the floor line, if the floor beams are of wood, is an opening 15 in. by 18 in. by 12 in. for the reception of the end of the floor beam. This means that at each floor line each outer brick pier has nearly one-half of its area cut away for the reception of the beam. In the concrete building nothing is cut away and the junction of the floor beam and column is absolutely rigid so that the entire frame when erected is as secure and stable as a riveted steel structure. Take the case of the interior columns; in the building of mill construction the first-story column will rest upon a cast-iron base plate and upon the top of this column will be placed a cast-iron capital and on the cast-iron capital a cast-iron pintle about 22 in. in height varying from 4 in. to 6 in. in diameter. There is no rigid connection

between the capital and the bottom of the pintle or between the top of the pintle and the next column, and this series of joints will continue up through the entire height of the building. At each floor line the cast-iron capital will support wooden floor beams, and these floor beams where joined at columns, are secured to each other by dog irons or joint bolts, but these do not add materially to the rigidity of the structure. Compare this interior construction with reinforced concrete construction where the floor beams and the posts are so rigidly connected that there is no chance of moving them in any way. In other words, the reinforced concrete structure becomes practically a unit from bottom to top.

An example of a reinforced concrete mill which will bring out some of the points mentioned, is the Maverick Mill in East Boston which was completed about two years ago. The main mill is 550 ft. long, 129 ft. wide, 2 stories and a basement in height and planned for two additional stories. The weave shed is about 341 ft. by 231 ft. and is at present large enough to take the looms which will be necessary for the machinery installed in the present two stories. In the future when the two additional stories are placed on the mill the shed will be doubled in size and the ultimate plan is to make the property consist of two spinning mills, four stories high and one large weave shed 681 ft. by 461 ft.

MODERN METHODS OF LIGHTING IN COTTON MILLS

By Albert L. Pearson, Boston, Mass.

Member of the Society

This paper is intended to call attention to some of the forms of illuminants and the underlying principles to be followed in making a layout for a cotton mill. As electric light has become the standard, it is the only one which will be considered. There are two principal forms of electric lamps, arc and incandescent, and there are several types of each.

There are a great many systems of arc lighting in use in mills today and some of them are quite satisfactory. The open carbon arc used with high-voltage constant direct-current generators has been displaced in general by the enclosed carbon arc operated in multiple on low-voltage direct or alternating current circuits. The intensified carbon arc is doubtless the best of this class and due to its design the principal objections to the other types of

arcs are practically overcome, that is the traveling of the arc around the crater causing varying shadows and the change in position of the arc relative to reflectors, thus interfering with the working of any well planned scheme of illumination. Flame arcs are not generally used indoors except in foundries, machine shops with very high roofs, or similar places. As the light is very penetrating, they possess advantages in smoky or cloudy atmospheres.

The mercury arc is finding a place in machine shops and textile plants, and is meeting with great favor in the silk industry. The principal objection to this lamp is the color of the light, a cold green; but it possesses two distinct advantages, great diffusion of the light due in a large measure to the fact that it emanates from a line rather than a point and the line distinction or clearness with which threads or lines may be distinguished. I believe it has been proved that this light does not produce injurious effects upon the eye, as noted from tests made by Dr. C. H. Williams and Dr. Louis Bell upon a number of persons who have worked in the light of this lamp. A fluorescent reflector is being developed which is intended to supply the missing red rays to a certain extent and thus make the light more natural. A new form of this lamp is also being developed, namely, the quartz tube, which will compete with flame arcs for foundries and similar places.

Of the incandescent class, the tungsten lamp is the most efficient, 1.25 watts per candle power as against 3.6 watts for the carbon lamp. The tantalum lamp falls about midway between these two for efficiency, namely, 2.0 watts per candle power. In its present high state of development, the tungsten lamp is practically free from the early defects. This lamp works equally well on alternating or direct current while the tantalum lamp gives best service on direct current; alternating current produces the effect of repeated blows and the filament breaks in a short time, higher frequencies having worse effect than low. This lamp, therefore, should not be used on alternating systems.

In addition to its efficiency the quality of light from the tungsten lamp is superior to that of other illuminants of this class, most nearly approaching the ideal. This lamp is the greatest competitor of the mercury arc, or Cooper-Hewitt lamp, and is being adopted as the standard of best practice for incandescent systems.

It is only during the past few years that attention and careful

study have been given to the proper arrangement of lighting systems in mills. There are a number of fundamental principles which should always be followed out in making a layout:

a As the operative is the one for whom the light is provided, he should be given every consideration.

b Lamps hung low down which can be adjusted by the operative should be avoided wherever possible. Not only is he liable to experiment with the lamp and waste time but may thus interfere with the work of other operatives.

c Lamps should be arranged to give uniform illumination at the working plane, avoiding shadows as far as possible and particular attention should be given to the requiren ents of each machine.

d White walls and ceilings are advantageous and add to the effectiveness of the lighting system. With individual driving of machines it is possible, owing to omission of overhead belts and shafting, to keep the rooms cleaner than with mechanical or group driving, thus benefiting the lighting system.

e On account of glare, low exposed units should be avoided. In places where it is necessary to have the lamps low down, reflectors which will entirely conceal the filament should be used. In such cases it is usually necessary to provide lamps close to the ceiling for lighting shafting, etc.

f The position of lamps should be carefully determined, both as to spacing and mounting height. In general the height of the lamp above the floor should be such that with the spacing available the lines representing the angles of maximum illumination with a given type of reflector will cross at the working place.

Each problem n ust be considered by itself. A system of illumination which works out well in one case may be anything but what is best suited for another. There are a number of points in favor of good lighting, viz: safety, better sanitary conditions, and better quality of work and increase in production.

The best lighting is provided for the most particular process—weaving. The amount of light and arrangement of lamps depend upon the nature of the work and character of the machines. In places where very good light is not required or where it is

used for comparatively short periods of time, obviously it does not pay to invest so much for this part of the equipment as in places where it is required for long periods or is depended upon for quality of work. But lighting systems cannot be worked out as formerly—so many watts or candle power per square foot—but a study must be made of conditions so as to produce a layout which will prove economical and bring forth results.

The distributing systems should be carefully worked out in order to secure good voltage regulation. Circuits and switching should be arranged with respect to different processes in such a way as to eliminate the use of power for lighting in sections not in use. On low frequency alternating-current systems small incandescent lamps should be avoided as much as possible on account of flicker, which is more troublesome with the higher efficiency lamps.

AIR CONDITIONING FOR TEXTILE MILLS

By Frederick W. Parks,[1] Fitchburg, Mass.

Non-Member

Artificial humidification is no longer a theory. For years it has been on trial in cotton manufacturing, and rapid progress has been made. Knowledge of the subject is becoming more general, and the needs for textile conditions are better understood by mill men and the practice is growing more standardized. Humidifiers are no longer considered as a luxury or a whim. Few new textile mills are now built without at least considering the need of humidifiers, and few cotton mills are now built without installing humidifiers at the start.

There are so many types of apparatus on the market that the engineer or mill owner should have no trouble in selecting one best suited to the needs of the case. Some are designed especially for new mills, others either for old or new plants, some for small isolated units, and so on.

Last fall in preparing a paper on the subject of Humidifiers and Their Results for the National Association of Cotton Manufacturers, the writer sent circular letters to textile plants throughout the country, and 81 mills replied. As evidence of the value of humidification, an analysis of the reports from these mills is highly interesting. They were as follows: the influence

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of humidifiers on production, floor sweeps, invisible waste, second quality goods, static electricity, broken ends in spinning, loom shut-downs, strength of product, mill temperature, health of operatives and estimated return on investment.

It is an interesting fact that not one unfavorable reply nor discordant vote of any sort was received. The experience of one mill (a Northern cotton yarn mill built about three years ago and humidified when built) is interesting enough to quote here: "Our invisible waste for 1911 was 1¾ per cent, which is very low. Our production was 93 per cent. Our regain from cotton to yarn averaged 6 per cent on 2,000,000 lb. of cotton per year. Our humidifiers cost $10,000."

There may be an honest difference of opinion as to how this regain should be figured. Six per cent of 2,000,000 lb. of finished yarn at 24 cents per lb. is $28,800 or 6 per cent of 2,000,000 lb. of raw cotton at 10 cents per lb. is $12,000. Either way you figure it, the humidifiers were a good investment. There are hundreds of such cases.

These reports were not obtained for the purpose of exploiting any particular make of humidifiers, for these 81 mills had 11 different types of humidifiers in use. They represented silk, rami, worsted and cotton mills, although cotton mills predominated. In numbers they were equally divided between the North and the South, so the reports may be considered as fairly representative of the textile industry.

In building a new mill, admitting humidification to be necessary, the next step is the selection of the proper type of apparatus. Some sort of system can be purchased at almost any price, but sufficient capacity should be made sure of. Higher humidities are being demanded right along. The man that asked for 65 per cent in cotton weaving five years ago is now demanding 75 per cent and wishing he could get 80 per cent.

Theoretically humidification is only one of three treatments that the mill air needs. The other two treatments are ventilating and heating, and these three functions combined may properly be called air conditioning. Some light may be thrown on this subject if the demand and peak load of each of these functions is considered so as to determine their relationship to each other.

a Heating

Demand—during cool months of spring and fall and cold months of winter.

Peak—usually between 3 and 8 a.m., and often a slightly lower peak after sunset on cold days.

b Ventilation

Demand—only for rooms thickly populated, and usually coincident with heating season.

Peak—no peak in average plant. Ventilation if required at all is in use only during working hours and load is very constant or none at all.

c Humidification

Demand—the season is longer than for heating or ventilating, greatly affected by goods made and natural surroundings.

Peak—come in cold and dry windy days of spring, fall and winter, also early mornings during heating season and especially Monday mornings when mill has dried out over Sunday.

From this brief analysis it will be seen that there is no close relationship between these three variables, for each must be capable of adjustment or operation at any load at times entirely independent of the other two, or in any possible combination with the other two. Take for instance, a zero morning in winter. The heating system may be run at peak from midnight till starting time; at 5 o'clock the metal will be warm and there will be no danger of precipitation and rusting, and thus the humidifiers may be started so as to have a proper amount of humidity when the power starts. With the starting of the power and the coming to work of the employees the ventilation is started at peak and maintained so all day. This air change may call for more humidity. By 8 o'clock the heat of the machinery and the improved circulation of air due to revolving shafting and belting have increased the temperature so that part of the heat can be shut off. By 9 o'clock more heat may be shut off if the sun is bright and there is no wind, yet the humidifiers and ventilation may not have been disturbed.

This condition may be maintained until noon, when the ventilation is shut off during the noon hour because the occupants have left. The humidifiers may or may not be shut off, depending on atmospheric conditions. At sunset more heat is needed, but the demand is not so great as in the early morning because the mill is full of warm machinery. At closing time the ventilation, humidity, and heat are stopped, and the process is repeated

the following day. Any working day in the year will call for a similar variation of these three widely varying functions.

It is obvious that the amount of ventilation is determined by the amount of odor or dust and the number of occupants. A weave shed with common looms, running four looms to the weaver would demand more ventilation than the same shed with Draper looms, running 16 looms to the weaver. It is also obvious that a thinly populated room in which an air change of once in five or six hours would comply with the Massachusetts school-house standard does not need to have its air changed every 20 minutes.

It is a fact that most textile mill heating and especially cotton mill heating comes outside of mill hours. It is somewhat startling, too, to learn that a mill located in Pennsylvania as an average of northern and southern locations, will need to run its heating system at full capacity less than 5 per cent of the total yearly heating hours. For New England the percentage is perhaps from 7 to 10 per cent. The rest of the heating hours the heating system is underloaded. It is necessary then to select a heating system which is capable of economical operation at less than full load, a point which is often overlooked. Many heating systems will operate at maximum efficiency only at peak load, with the resultant evils at light load of overheating and waste of fuel. And in cotton manufacturing especially, overheating may prove very expensive from the standpoint of product.

DISCUSSION

In the discussion which followed the presentation of these three papers, the question of suitable floors under the new conditions of concrete mill construction was touched upon extensively. Mr. Reynolds, in reply to a question regarding dusting of concrete roofs and floors, stated that he had effectually prevented dusting by the use of just enough oil in the floors to keep the surface fairly well polished. In the spinning alleys the floors kept just like glass. Of course, the trucks knocked out or chipped out pieces occasionally and these became holes, but they filled up rapidly. Some floors have been treated successfully with boiled linseed oil. As to the matter of trucking, Mr. Reynolds expressed his opinion that if the proper amount of cement were put in the concrete and if it were properly troweled down, no trouble would be experienced if trucks having wide wheels were used. As to

experience with factory operatives, he referred to a case where, in the original section of an automobile factory, wooden floors were used, but in later extensions, concrete floors were tried and proved so successful that the wooden floors were finally eliminated from the entire plant.

F. W. Dean referred to a case where steam pipes had been embedded in the concrete floors to enable them to be heated for preventing complaints from the operatives against coldness of the floors. For hard usage, however, he favored wood blocks for floors of factories and machine shops and referred to a mill he had designed in which wood block pavements had been used for floors with very satisfactory results under hard trucking service.

S. E. Thompson did not share the belief that concrete floors could be built successfully to withstand trucking. He referred to a test which he had made in order to determine what precautions were necessary to provide good wearing qualities in a concrete floor and pointed out the fact that an exceptionally good surface for the floor would not be glossy but would wear and dust; furthermore, in wearing down it would become a dead white color. One of the chief points in making a proper surface was found to be in the use of a sand of fine aggregate but which was not dust; this seemed to be a simple matter, but he stated that most of these floors were made of ordinary bank sand.

Henry Bartlett told of some experience with concrete floors in railroad shops in which difficulties were experienced, not because the floors were cold, but because they were hard. He had found that concrete floors would not stand heavy trucking and the rolling around of locomotive driving wheels. Floors constructed of spruce planks with maple flooring on top had been tried but would not stand up under these conditions, and subsequently heavy creosote wood blocks were tried with better results.

A. L. Williston referred to his experience with concrete floors in school laboratories and school shops, in which a great deal of difficulty was experienced with dust and grit from the floor surface and expressed the opinion that the life of machinery installed on concrete floors was thereby reduced. He touched upon the condition which caused this disintegration of the floor and stated that a microscopical examination of a concrete floor surface would not show a solid mass, but rather particles of the aggregate with very appreciable open areas between them; the

surfaces of the sharp sand particles did not come together, but the points of them frequently came together and occasionally overlapped. It was from this cause that trucking and hard usage tended to disintegrate the surface structure and it was suggested that if means were found of filling up these voids with some sort of an elastic cement, better results would be obtained with the floors. A few of the large paint manufacturers had been conducting rather extensive experiments to find out what materials would go into the concrete and satisfactorily fill up these voids, or at least the largest part of them, but most of the information which they have obtained was inaccessible. A trial of one compound manufactured by a Philadelphia concern was found to make a great difference in wearing qualities of the concrete floors; the compound seemed to fill up these voids and make the cushioning effect which resulted in the perfect condition of the floors. It was the speaker's experience, however, that people did not like the hard unyielding surface of the concrete floor to stand on all day. Neither the students in the laboratories nor the instructors liked them and they could not become accustomed to it. While he agreed that in a great many industrial plants, the disadvantages of the concrete floor were unquestionably offset by its advantages, he felt that the wood blocks installed on end in concrete was the best floor construction that could be used.

Mr. Parks, in reply to a question concerning humidity control, stated that the distribution of the humidifying apparatus over the average textile mill was determined largely by the percentage of humidity that was needed in the various processes of manufacture, the most common practice being to have the apparatus distributed fairly frequently over the mill. In fully 90 per cent of the textile plants, the humidifying process was applied independently of ventilation. Of course, in many of the older plants, ventilation was obtained merely by opening the windows, but in recent years more attention had been given to this matter. So far no ill effects had been observed from the use of humidification on the health of the operatives, although he suggested that if a high humidity, say above 80 per cent, were used, it might begin to be harmful. He stated that it was now viewed by the medical profession as advantageous to provide humidity regulation, and referred to some machine shops that had put in some kind of air-conditioning apparatus from the standpoint of benefit to the operatives, while others had made

use of humidity control from the standpoint of removing smoke and dust.

E. D. Lyle stated that humidifiers were used in lithographing plants and in many processes of manufacture where a fiber was used; in processes of this kind and in many plants where gases were used, humidifying was very advantageous. Candy manufacturers, film manufacturers and tobacco manufacturers were perhaps the largest users of this process, although the field had grown and was growing constantly and it could not be predicted where it would stop.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

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The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Review. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Not so very long ago a man thought that he knew everything about his engine if he had taken an indicator card. This is no longer so. Of late, it has become more necessary than ever, from an economical standpoint, to produce power as cheaply as possible, while the appearance of comparatively new sources of power, such as the gas producer and gas engine, has made an exact determination of costs and efficiencies more valuable than before, such data being used for determining the selection of the prime mover, a state of affairs which did not exist in the days when the selection was limited to the reciprocating steam engine. We witness therefore an appearance of a series of methods for a better and more practicable use of indicator diagrams, indicating devices, etc. In this country this tendency has found an expression in the beautiful work of Mr. Clayton published in *The Journal* last year.

THIS MONTH'S ARTICLES

Among this month's articles will be found an abstract of a paper by Mr. Leinweber on Diagram Characteristics which, though not of as fundamental a character as Mr. Clayton's, will be of great interest especially to internal-combustion engineers. The same tendency to break away from the somewhat loose methods and conceptions of a few years ago is manifested in Professor Bouasse's discussion of the Young modulus in which he shows that the current definition of this coefficient covers only a particular case, a general definition being also given. The article by Dumanois on the application of Diesel engines to driving battleships brings out a fact which, though not entirely novel, has not yet become fully known, viz., that at certain periods of operation, the actual pressures in Diesel engines may be three or four times as great as the normal pressures, a fact of considerable importance when it is remembered that the normal pressures are as high as 35 atmospheres. The attention of steam engineers is called to the description of tests made at the

Bollinckx Company's works in Belgium to determine the methods of prevention of the somewhat mysterious phenomenon known as water hammer. These tests have shown that a few simple precautionary measures are all that is necessary. Attention is also called to the article on welding of steam boilers and the data on some boiler explosions in Germany, interesting in showing how thoroughly each accident of this kind is investigated on the other side of the water. Reference to the description of the Mestre Squirrel Cage Superheater has already been made in *The Journal* for May. In compliance with a number of requests and inquiries, a full description of this device is given in this issue. Refrigerating engineers will be interested in the New Tables and Diagrams for Sulphurous Acid, by Dr. Hýbl. On account of their importance, the tables are fully reproduced, but it was not thought advisable to reproduce the entropy diagram, since, in its reduced form, it could not be used for practical purposes. In the section Miscellanea will be found a defense of the Taylor system of management by H. Le Chatelier, interesting both because of the prominence of the author, and the lucid manner of meeting the stock objections made to this system.

Air Machinery

New Designs of Turbo-Blowers and Turbo-Gas-Exhaustors for Metallurgical Plants (*Neuere Ausführungen von Turbogebläsen und Turbogassaugern für Hüttenwerke*, Ernst Blau. *Die Fördertechnik*, vol. 6, no. 4, p. 77, April 1913. 5 pp., 9 figs. *d*). Description of new types of turbo-blowers and turbo-exhaustors built by Brown, Boveri & Co., of Baden, Switzerland. Fig. 1A and B shows the operating characteristics of this type of blower. Fig. A has been obtained from tests of a blower without water cooling, compressing 1200 cbm/min. (say 42,000 cu. ft. per min.) to 320 mm (12.5 in.) mercury, and driven by a combined turbine running at 2900 r.p.m.: *a*, *b*, *c* and *d* are pressure-volume curves, *a'*, *b'*, *c'* and *d'* steam consumption curves, and η efficiency curve. The amount of air taken in has been determined in the usual manner by means of a calibrated nozzle, the various amounts and pressures being obtained by varying the position of a hand wheel on the turbine governor. Fig. 1B gives data for a blast-furnace blower designed to deliver 850 cbm/min. (30,000 cu. ft. per min.) compressed to 250 mm (9.8 in.) mercury, driven by an electric motor: *a* and *b* are pressure-volume and power-volume curves respectively, *c* is the limiting curve for constant load.

The article further describes the construction of a turbo-blower for supplying air at a higher pressure to converters. The following device is used to equalize axial thrust in single end blowers: behind the last runner on the shaft is wedged on a disc running between two labyrinth

packed surfaces in front of a closed chamber. When the final pressure of the compressor becomes too great, it spreads through a slot in front of the disc to a space behind it, and the shaft is displaced towards the suction side of the blower by the pressure acting on the comparatively large rear surface of the disc. At this moment the slot in the rear labyrinth packing opens a little, a communication between the back space and the atmosphere is established, and as a result the pressure on the rear surface of the disc falls off and the shaft returns to its initial position. In actual

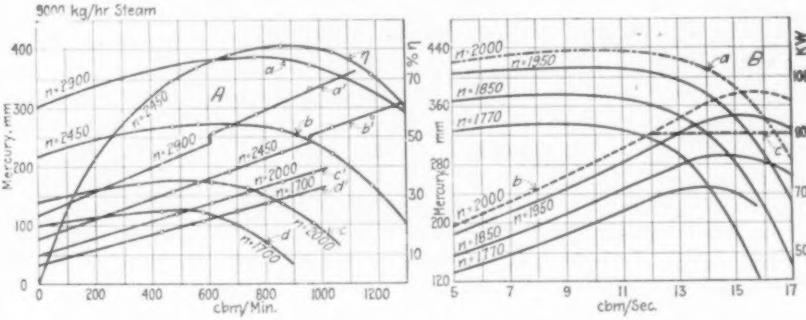

FIG. 1 OPERATING CHARACTERISTICS OF THE NEW BROWN, BOVERI & CO. TURBO-BLOWER

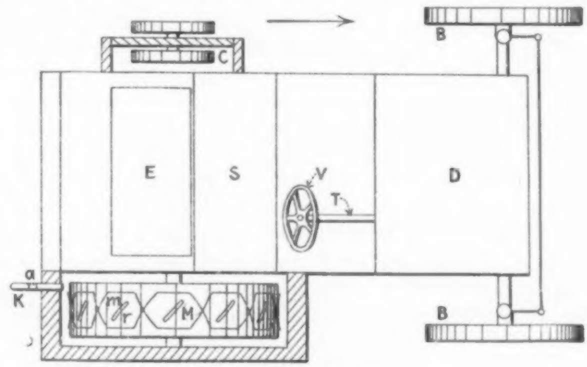

FIG. 2 GILBERT TRACTOR

practice the pressure equalization occurs with such rapidity that to all practical purposes the disc is always in its middle position. This arrangement is automatic, and has the advantage of making unnecessary the installation of a high-pressure stuffing box. The collar thrust bearing serves only to keep the shaft in position, but not to take up the axial thrust.

Farm Machinery

THE GILBERT TRACTOR (*Le tracteur de M. Gilbert*, Fernand de Condé, *Bulletin de la Société d'Encouragement pour l'industrie nationale*, vol. 119, no. 3, p. 481, March 1913. 1½ pp., 1 fig. *d*). The Gilbert tractor has five wheels: the two front wheels (Fig. 2) *B* are guiding wheels; two small

wheels on the left in the rear are in one piece and on the same axle, and are acting as road wheels; the large wheel on the right is the driver. The front wheels are connected with the underframe by means of a central steering swivel which permits of a considerable displacement of the wheels in the vertical plane with respect to one another, and a great obliquity with respect to the two axles, without impairing the stability of the tractor. To increase the adherence, the rim of the driver *M* is provided with striæ *m*, and in addition, steel plates are arranged to come out through the slots *r* and penetrate into the ground; while in the upper part of the wheel they disappear completely inside the rim, in the lower they stick out about 0.12 m (4.72 in.); this is achieved by fixing these plates to levers disposed in a manner around the hub such as to have a motion eccentric to that of the wheel; this arrangement helps also to rid the wheel and the plates of earth that might otherwise stick to it. When the tractor is traveling on common roads, i.e., doing no field work, the plate device is turned through 180 deg., so that the plates stick out of the upper part of the rim, and do not interfere with the motion of the tractor. The draw-bar *K* can be moved from *a* to *b* in accordance with the resistance met with by the tractor. *D* is the engine (an explosion engine of 12 h.p.), *S* the seat, and *E* gasolene tank.

Hydraulics

WATER HEAD OF *1650* METERS (*Une chute de 1650 mètres. Journal du four électrique*, vol. 22, no. 398, 169, April 15, 1913. 1 p. *dh*). The author indicates briefly the stages in the adoption of higher and higher heads of water in hydraulic plants, and gives some data of the hydroelectric plant of the Société d'Electrochimie, of Paris, France, now under construction. This project proposes to use water power from lake Fully, in Valais, France, with a head of 1650 meters (5415 ft.) The conduit is to be 4½ km (2.8 miles) long made of steel tubing from 600 to 500 mm (23.6 to 19.6 in.) in diameter, and with walls 6 to 45 mm (0.23 to 1.77 in.) thick. In the upper part tubes will be welded by water gas; in the lower part, which is to support pressures up to 165 atmospheres, welded tubes would not be strong enough and therefore cold drawn tubes are to be used. The project calls for four Peltons wheels, each of 3000 h.p. at 500 r.p.m.

NEW TURBINE PENDULUM GOVERNORS OF THE DE TEMPLE GOVERNOR CONSTRUCTION COMPANY OF LEIPZIG (*Neue Turbinpendel der Regulatorenbau-Gesellschaft de Temple in Leipzig*, O. Moog. *Zeits. für das gesamte Turbinenwesen*, vol. 10, no. 11, p. 161, April 20, 1913. 5 pp., 5 figs. *d*). According to the author's definition, a turbine pendulum governor is a centrifugal governor to be used in the first place for governing engines with a constant moment of torsion, such as water, steam and gas turbines, as opposed to reciprocating engines having a variable moment of torsion. To make governors economically and well, they must be produced in large quantities, which requires the use of special machinery. It did not pay turbine makers to go in for governor manufacture also, which consequently had to be taken up by special factories; the latter in their turn had to make the governors so that they should be good for as many uses as possible, and therefore to design them so that their main part should

apply to apparatus, notwithstanding the purpose for which it was to be used; the difference in the various kinds should lie only in the secondary appliances. This was the way followed by the de Temple Governor Construction Company of Leipzig whose pendulum governor is described in the article. The description of the governor is preceded by some theoretical considerations which, though not entirely new, do not appear to have been presented in an English publication in the same way.

Let E be sleeve pressure of the pendulum; δ coefficient of cyclic variation of the pendulum; δ_1 coefficient of cyclic variation of the regulation; ϵ_r coefficient of insensitiveness of the pendulum caused by governor friction; ϵ total coefficient of insensitiveness; s lift of sleeve of pendulum; s_r reduced lift of sleeve of pendulum; μ_r reduced mass of pendulum; T_a starting time of the engine; T_s closing time of the regulation; T_1 relative closing time of the regulation; T_p natural period of oscillation of the governor; T_r period of oscillation of the regulation, C_1, C_2, C_3 ... constants.

As shown by Tolle, in the case of a direct regulation of an engine the most advantageous coefficient of cyclic variation is determined by the equation:

$$\delta = \delta_1 = C\sqrt[3]{\frac{s_r}{T_a^2}} \quad \ldots\ldots\ldots\ldots [1]$$

and in this case the coefficient of insensibility has to be made $\epsilon \geqq C_1 \delta\, x$, where x is the relative load variation. A small coefficient of insensibility would lead to the pendulum oscillating all the time, while a perfectly sensitive pendulum could not be used at all. δ can decrease with the decrease of s_r, or with the increase of T_a, but in machinery without periodic variation of the moment of torsion, the starting time is made, from economic considerations, as short as possible, and the decrease of the coefficient of cyclic variations can be effected only by reducing s_r. In the case of pilot valve governing the closing time T_s and the coefficient of cyclic variation of the regulation must also be considered. The condition of stability, requiring that after a load variation the engine should pass into its new state of equilibrium without oscillations, is as follows: the natural period of oscillation of the pendulum T_p should be small as compared with the period of oscillation of the regulation T_p and T_r, which are respectively

$$T_p = 2\pi\sqrt{\frac{\mu_r\, s}{2E\delta}} \quad \ldots\ldots\ldots\ldots [2]$$

$$T_r = 2\pi\sqrt{\frac{2C\,\delta\, T_1}{75\, Ns}} \quad \ldots\ldots\ldots\ldots [3]$$

These equations are further transformed by the introduction of the following values for s_r, T_a and T_s:

$$s_r = \frac{g\mu_r s}{E}; \quad T_a = \frac{2C}{75N}; \quad T_s = \frac{T_1}{s} \quad \ldots\ldots\ldots\ldots [4]$$

the last on the assumption that the governor velocity is proportional to the displacement of the pendulum sleeve out of its median position. Equations [2] and [3] then take the form:

$$T_p = 2\pi\sqrt{\frac{s_r}{2g\delta}} \qquad \text{[2a]}$$

$$T_r = 2\pi\sqrt{T_a T_s \delta} \qquad \text{[3a]}$$

the equation of irregularity of the governor (Stabilitätsbedingung) taking the form:

$$\frac{T_p}{T_r} = \sqrt{C_2}\sqrt{\frac{s_r}{T_a T_s \delta^2}} \ll 1 \qquad \text{[5]}$$

The usual expression for the maximum speed deviation, in revolutions, in the case of pilot valve governing, is:

$$z = \frac{\Delta\omega}{\omega_m} = C_3\sqrt{\frac{75N}{C}\frac{\delta T_1}{s}x} \qquad \text{[6}$$

where x is the relative load variation. With the values given in [4], this becomes

$$z = C_3\sqrt{C_4}\sqrt{\frac{\delta T_s}{T_a}}x \qquad \text{[6a]}$$

From a consideration of equations [5] and [6a] it appears that the value of δ in most cases is fixed, and must not exceed a certain definite limit. While it would appear from [5] that T_s be selected as large as possible, equation [6a] is against that by showing that with respect to the maximum permissible speed deviation it is advisable to make T_s as short as possible. It is not economic to make T_a larger than otherwise necessary, and therefore the best way to limit the irregularity of the governor appears to be still to make the reduced lift of sleeve of pendulum small. Insensitiveness of the pendulum is particularly harmful in the case of pilot valve governing, since it not only increases the maximum speed deviation, but also the irregularity of the governor. On the other hand, a perfectly sensitive pendulum is also inapplicable owing to the impossibility to make a pendulum having no mass. The rise of periodical oscillations is prevented by the action of forces in the pendulum itself, but insensibility of the pendulum, while in its equilibrium position, is harmful in that it prevents the pendulum from exercising at once its regulating influence: insensitiveness of the pendulum should therefore come into play only after the beginning of the governing action. The de Temple governor itself will be described in an early issue of *The Journal*.

Internal Combustion Engines

Variable Stroke Engine (*Le moteur à course variable*, G. Lienhard. *La Technique automobile et aérienne*, vol. 8, no. 88, p. 52, April 15, 1913. 3 pp., 5 figs. *dt*). Principles of operation of the new valveless variable stroke internal-combustion engine, Itala, in which the usual system of change speed gears and transmission by crank and connecting rod are replaced by the novel arrangement shown in Fig. 3A (the connecting rods shown by their axes only). The piston *A* is free to move in a cylinder (not shown); the connecting rod *B* articulates in *a* with the piston, and in *b* with another connecting rod B_1 in its turn having a further connection in *c* with the crank *M* of wheel *R*, in mesh with an endless screw in

a way such that it may either move and turn the crank with it, or be kept in any desired fixed position. In *b* also is articulated a third connecting rod B_2 engaging at its other extremity the crankshaft of the engine. If the wheel *R* is held stationary while the engine runs, the piston will have a reciprocating motion at constant amplitude. But if the wheel *R* be given a rotary motion, with *c* describing a circle about *o* as a center, while the engine runs, the amplitude of reciprocating oscillations of the piston will vary. The author analyzes in detail the variation of the stroke, and to do this solves an interesting problem: being given two cranks of any length connected by a connecting rod of any length, to determine the movement of one of the cranks from that of another. This part of the article is not suitable for abstracting. No data as to actual tests of the Itala engine are given.

DIAGRAM CHARACTERISTICS (*Diagramm-Characteristiken*, B. Leinweber. *Zeits. des Vereines deutscher Ingenieure*, vol. 57, no. 14, p. 534, April 5, 1913. 9 pp., 27 figs. *etA*). The usual method of investigating thermo-

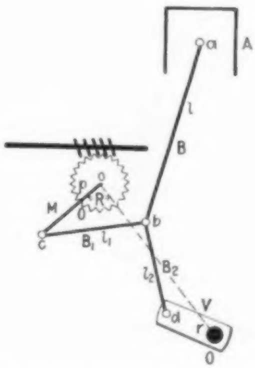

FIG. 3 VARIABLE STROKE ITALA ENGINE

dynamically indicator diagrams is to draw an isothermal or adiabatic curve through the origin of the compression or expansion line, or to compare the expansion (compression) line with a polytropic curve plotted to a polytropic coefficient *n approximately* corresponding to that of the actual expansion line. The angle φ is selected as above, and from it is determined, by the formula $1 + \text{tg}\ \psi = (1 + \text{tg}\ \varphi)^n$, the angle ψ which is then used to draw the ideal polytropic curve $(=n)$ in the usual manner. This process is however little suited for the actual determination of thermodynamic processes since actually the diagram lines do not follow the ideal coefficient *n*, but their polytropic coefficient varies continuously. To draw ideal polytropic curves through every point of the diagram is not practical, and the author suggests a different method for plotting the characteristic curves: Divide the abscissa to a given line of change of state (Fig. 4) in a manner such that $\frac{v_1}{v_2} = \frac{v_2}{v_3} = \frac{v_3}{v_4}$; draw through the points of division perpendiculars to the abscissa, and draw, until their intersec-

tion with these perpendiculars, lines, at 45 deg. to the preceding line, from the point of division next to it: a straight line of proportionality is then obtained enclosing an angle ϕ, the dimensions of which depend on the ratio $\frac{v_1}{v_2}$. If now parallel lines be drawn from the corresponding points of the expansion line to the abscissa, and from their points of intersection with the zero-ordinate straight lines be drawn at 45 deg. to the ordinate, points of intersection are obtained which, when connected with the origin of the coördinates, give a line which, together with the ordinate, encloses an angle ψ satisfying, for the corresponding point of the expansion line, the equation $1 + \text{tg}\,\psi = (1 + \text{tg}\,\varphi)^n$. In the case of the ideal polytropic curve of change of state, all these points of intersection lie in a straight line, the angle ψ being constant when n is constant. In actual diagrams the coefficient n is not constant, the angle ψ varies, and the line connecting the points of intersection is not straight line, but an irregular curve.

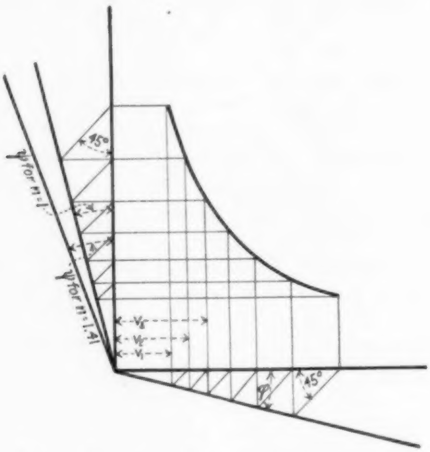

Fig. 4 Indicator Diagram Characteristics

By drawing from the origin of the coördinates two straight lines, one with angle ψ for $n = 1$ (isothermal) and the other for $n = 1.41$ (adiabatic curve), one can observe the variations of the coefficients n for different angles ψ as compared with these curves, and how the diagram oscillates between these two changes of state. The main part of the article devoted to the application of this method to the investigation of internal-combustion engines is of interest in showing how much information as to the working of such engines can be obtained from indicator diagrams with a proper method of interpreting them, but cannot be abstracted here owing to lack of space.

Application of Diesel Engines to War Vessels (*Application des moteurs Diesel aux navires de guerre*, P. Dumanois. *La Technique moderne*, vol. 6, no. 8, p. 289, April 15, 1913. 6 pp., 4 figs. *c*). The author believes that Diesel engines are not suitable for driving *war vessels*. Let P, p_m and

N be the maximum pressure, average ordinate and number of revolutions per minute of a steam engine, and P', p'_m and N' the same quantities respectively for a four-stroke cycle Diesel engine of equal power and strength. It may be admitted that the weight of an engine per horsepower is a function of these quantities:

$$W = A \frac{P}{p_m N}$$

and in the case of a Diesel engine

$$W' = 4\ A \frac{P'}{p'_m N'}$$

Hence

$$W' = 4\ W \frac{P'}{P} \frac{p_m}{p'_m} \frac{N}{N'}$$

but, since P, P', p_m *and* p'_m are constant for given apparatus, there is an advantage in increasing N' in order to reduce W'. But in the steam engine of say 6000 h.p., N is about 400 r.p.m., which is also about the maximum for N' (speed of a Diesel engine), so that $N = N'$. Since further (in atmospheres) $P = 17.5$; $P' = 35$; $p_m = 4$; and $p'_m = 7$; $W' = 57$ kg. (125 lb.) for a four-stroke cycle engine and approximately 40 kg. (88 lb.) for a two-stroke cycle engine, which is considerably in excess of the corresponding weights in the case of a steam engine (the author shows that taking into consideration the weight of the fuel, etc., the weight of a Diesel engine per horsepower must not exceed 31 kg. or 68 lb., in order to be equal in efficiency per lb. of weight to the steam engine). But the author shows further that the maximum gage pressure of 35 atmospheres in the Diesel engine when normally operating does not at all indicate the actual maximum pressure which under certain conditions may be three times as high; this will cause mechanical fatigue of the materials used and impair the reliability of the engine. Therefore, even with an engine exceeding in relative weight the steam the coefficient of reliability would be lower for the Diesel engine, and to make them as reliable as steam engines, they would have to be designed for maximum pressures up to 115 atmospheres for four-stroke cycle engines, and 80 atmospheres for two-stroke cycle engines, which would make their weight absolutely prohibitive for use on battleships. To this must be added the difficulty of construction of large bore Diesel engines, which increases more rapidly than the size of the engine. Attention of internal-combustion engineers is called to the author's discussion of the processes producing pressures three or four times larger than the normal maximum pressure: abstract cannot be given on account of lack of space.

THE MODERN GAS ENGINES AND THEIR ECONOMIC POSITION (*Die neueren Gasmaschinen und ihre wirtschaftliche Stellung*, H. Neumann. *Journal für Gasbeleuchtung*, vol. 56, no. 15, p. 341, April 12, 1913. 5 pp., 12 figs. *cd*). From a paper read at the 44th annual convention of the Silesian Gas and Water Engineers Association. The author believes that the progress of the small electric motor in the industry is due to a large extent to the greater flexibility of the electric tariffs as compared with the rigid gas rates, as well as to the fact that hitherto the first cost of gas engines

was somewhat higher, and the attendance less simple than with an electric motor. Lately however new types of extremely simple and practically fool-proof gas engines have been placed on the market, some of which the author describes: In the Deutz *naphthaline engine* the naphthaline is vaporized by boiling cooling water, the feed pipe conducting naphthaline vapor from the vaporizer to the atomizer being surrounded by steam, in order to prevent condensation of the vapor. Until the cooling water is heated up to the boiling point, which takes about ¾ hours, the engine is driven by gas or benzole. From data given in the article it appears that in Germany the naphthaline engine, in sizes of say 6 h.p., becomes more economical than the gas engine when operated at the rate of 1750 and more hours per year, the economy in favor of the naphthaline engine increasing as the number of working hours per year grows.

Mechanics

COMBINED OIL AND GRAPHITE LUBRICATION (*Kombinierte Oel- und Graphitschmierung*, H. Putz. *Dinglers polytechnisches Journal*, vol, 328, no. 17, p. 257, April 26, 1913. 3 pp. *pt*). Exposition of the Ubbelohde theory of lubrication, mainly in connection with the problem of graphite and graphite-oil lubrication. For a detailed statement of the Ubbelohde theory see *The Journal*, June 1912, p. 963, and August 1912, p. 1245.

CONCERNING M. BRENIER'S ARTICLE ON THE STUDY OF SPRINGS (*A propos de l' étude sur les ressorts de M. Brenier*, Maréchal. *Bulletin de la Société de l'Industric minérale*, April 1913. p. 471, 5 pp., *p*). The author, chief equipment engineer of the Paris-Lyon-Méditerranée Railroad, France, calls attention to the fact that his company has been using for 20 years a formula for the design of laminated springs analogous to that established analytically by Brenier, which proves the correctness of Brenier's method (for an abstract of the article of Brenier see *The Journal*, August 1912, p. 1250).

DEFINITION OF YOUNG MODULI FOR VERY DEFORMABLE BODIES (*Définition des modules pour les corps très déformables*, H. Bouasse. *La Technique moderne*, vol. 6, no. 9, p. 325, May 1, 1913. 3½ pp., 6 figs. *etA*). The author criticises the usual *definition of coefficient of elasticity* as the load which would be necessary to elongate a piece of 1 sq. in. section to double its original length, provided the proportionality of elongation to tension which holds for small tensions, would continue indefinitely. The author calls attention to the fact that this definition is usually applied to all solids indiscriminately. This classical definition means that if Fig. 5A (tension test curve, abscissae elongations, ordinate stresses) the Young modulus is measured by the angular coefficient of the curve at the origine *O*, inclination of the tangent at the start, for small loads. But there is nothing to prevent anyone from considering the point *A* instead of *O*, and since the inclination of the tangent is different there, from obtaining an infinite number of continuously varying moduli. To the objection that this cannot be done because at *A* there is a *permanent set*, the author replies: how do you know this except through assuming that each curvature of the curve of tension corresponds to a permanent set? He proceeds to

prove that this is not so. He maintains that a really elastic deformation corresponds to a reversible operation. If the curve *OAB* (Fig. 5A) corresponded to really elastic phenomena, it would not matter in which sense it was taken since, whether for decreasing or increasing loads, the same points would correspond to the same stresses. Generally, however, the curves for increasing and decreasing loads look more like Fig. 5B (for rubber). Since further, the Young modulus, by hypothesis, is supposed to represent a characteristic parameter of actual elastic phenomena which, also by hypothesis, are characterized by the superposition of their curves for increasing and decreasing loads, the inclination of the tangent at some point, say at *B*, cannot be considered as characteristic for the modulus, since the tangents for increasing and decreasing loads are entirely different, and, as seen from Fig B, may be twice as large for decreasing loads as for increasing.

The author proposes to proceed in a manner different from the usual

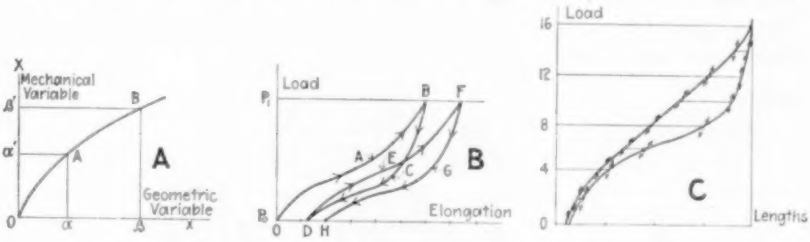

FIG. 5 TENSILE STRESS-ELONGATION AND RESIDUAL ELONGATION CURVES

one. Starting from some point *A* on the curve corresponding to a load *P*, he produces slight variations of load from $\triangle P - \triangle P$ to $\triangle P + \triangle P$. He describes successively small curves for increasing and decreasing loads *quasi rectilinear and with inclinations tending towards the same limit.* If this operation be repeated a great number of times, two little straight lines will be described exactly superimposing, and be such that their middle point corresponds to the load *P* and length *L*, and the inclination represents the Young modulus for the point in the plane having for its coördinates *P,L*. With a certain thread (rubber) of a definite length and the same person performing the tests it is not possible to obtain all the points on the plane (*P,L*), but a considerable area of that plane. The moduli at all these points may therefore be defined as follows: the inclination of small stretches of the curves, formed practically by two superimposed lines have to be determined, and from this is derived the Young modulus (taking into consideration the personal coefficient of the experimenter, and the area). This definition includes the classical definition as a particular case, but has the advantage of indicating when it may be legitimately used. It shows that to obtain the characteristic inclination from which the modulus might be derived, the condition of operating at small loads is not sufficient and in addition the effect of repeating a small cycle at light loads has to be eliminated. Fig. 5C is interesting in that it shows to what extent the inclination of small *fixed* cycles can differ from that of a large curve passing through their middle points. The im-

portance of this new difference is more evident when applied to materials, such as rubber, than in connection with metals. One of the characteristics of such heterogenous materials, however, is that they *age*, which means that under certain conditions their tensile strength rapidly falls with time. One of the conditions which, in the case of rubber, appears to produce ageing with particular rapidity is rest; it is therefore of advantage to have some methods for determining the progress of ageing without accelerating it, and experience shows that one of the characteristics of the ageing process is the hardening of the material, the increase of its Young modulus; rubber with a small modulus of elasticity (perfectly pliable) becomes petrified at the end of say six months (very large coefficient of elasticity). The author describes a method of determining the coefficient of elasticity of the material by subjecting it to a series of small stresses which neither act destructively nor accelerate the process of ageing. The importance of his process, as the author claims, lies in the fact that it is scientific, and that it gives results which mean something definite. The apparatus used is very simple, and would probably be of interest to manufacturers of tires and balloon materials.

Pumps

PACKING AND STUFFING BOXES IN CENTRIFUGAL PUMPS (*Dichtungen und Stopfbüchsen bei Kreiselpumpen*, A. Schacht. *Die Fördertechnik*, vol. 6,

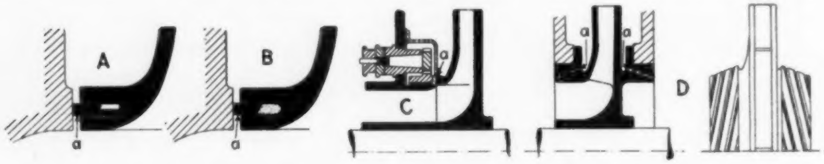

FIG. 6 STUFFING BOXES IN CENTRIFUGAL PUMPS

no. 4, p. 82, April 1913. 2 pp., 13 figs. *d*). A compilative description of various types of packing and stuffing boxes in centrifugal water pumps to avoid clearance losses. Several of the devices described are of American origin, and therefore omitted here. Fig. 6A represents a device patented in Germany (No. 142,214, Klasse 59 b). A packing ring *a* loosely set in the blade wheel is pressed against the casing wall by a sectional inner ring, the sections, under the action of centrifugal force, producing a good contact and thus eliminating clearance losses. In another type of the same design (Fig. 6B) packing material is used instead of the sectional ring, the action likewise depending on centrifugal force. In the German patent No. 117,218 (Fig. 6C) the packing ring *a* is adjustable, and so arranged that it may be adjusted from outside. This packing ring is provided with screw threads, to prevent its pressing too hard against the blade wheel; when the pressure becomes too great, the blade wheel itself screws it back into the casing. Apart from the fact that this stuffing does not apply to multistage pumps, it would have been very good, if it were not so costly. In the Austrian patent No. 35,965 (Fig. 6D) the packing is produced partly by the use of helical grooves, but mainly by the action of centrifugal force, and to increase the action of the latter the depth of

the grooves is made progressively increasing. This device ought to be very effective in view of the fact that the centrifugal force increases as the square of the diameter of the increasing grooves, and therefore there ought to be at *a* a pressure sufficient to make a good packing joint. The article does not state if any of these types are in actual use.

Steam Engineering

STEAM DRYING (*Das Trocknen des Kesseldampfes*. C. Guillery. *Organ für die Fortschritte des Eisenbahnwesens in technischer Beziehung*, new series, vol. 50, no. 8, p. 140, April 15, 1913. 1 p., 1 fig. *dp*). Since the introduction of superheated steam, steam drying has been somewhat neglected, but is really more important than ever, because the heating area has grown more rapidly than the surface of evaporation, the amount of evaporation per unit of heating area has, in locomotive practice, increased with the increased speed of runs, while the path of the steam bubble from the fire tubes and walls of the fire box inside of the boiler has become longer. In addition, the water surface in a locomotive boiler, owing to stronger vibrations due to the greater speed of the locomotive, has become less steady than before, while the steam domes have become lower as the boiler diameter increased. All these factors are conducive to higher water content in steam, and the drying of the steam ought not to be entirely left to the care of the superheater: the locomotive will work of course, but the efficiency of the superheater will be lower. The article contains also a brief description of the *Born separator* (centrifugal type) with which tests were made on a private suburban line and have shown an economy of 7.5 per cent in the amount of water used. No exact data as to the methods of testing are given.

WATER HAMMER IN STEAM ENGINES (*Les coups d'eau dans les machines à vapeur*, F. Gyseling. *Revue Industrielle*, vol. 44, no. 2081/16, p. 209, April 19, 1913. 3 pp., 14 figs. *eA*). Data of experiments made at the plant of the H. Bollinckx Machine Company, Brussels, Belgium (the author is technical director of the company). For the tests a single cylinder engine was used, having diameter of cylinder 350 mm (13.7 in.), stroke 700 mm (27.5 in.), speed 158 r.p.m., admission steam pressure 7.5 atmospheres, normal power 140 i.h.p. The valve gear is by horizontal piston valves with trip gear for admission and positive gear for exhaust, the admission catch acted on by a centrifugal governor which permits varying the degree of admission from 0 to 55 per cent; exhaust lead 10 per cent, and compression lead 25 per cent; clearance only 3 per cent of the useful volume of the cylinder. The engine was built to use saturated steam. To determine more precisely the influence of water carried into the cylinder by the admission of steam, the condenser was disconnected, and the engine run with free exhaust into the air. To allow the water flowing from the cylinder to move more freely, the discharge piping having a diameter of 170 mm (6.6 in.) was set with a slant towards the outside; the exhaust steam was allowed to escape through the end of the piping, at the floor level. To make the damage due to the action of water hammer as slight as possible, special precautions have been taken. By putting out of action the front catch, the engine was made single acting, so that a water ham-

mer could be produced only in the back of the cylinder. In that case it would break off the cylinder cover which, for this particular reason, was fastened by only three bolts, and after being blown off, would strike pieces specially placed for that purpose some 5 cm (say 2 in.) away. During the tests the flywheel was connected by a belt with a pulley set on the main power shaft of the shop driven by a large motor. Owing to this arrangement the engine could not run away even while running at no-load with a large admission, because the shop shaft was driven by a motor far more powerful than the engine under test; on the other hand, with the belt thrown off from the flywheel and a large admission, very acceler-

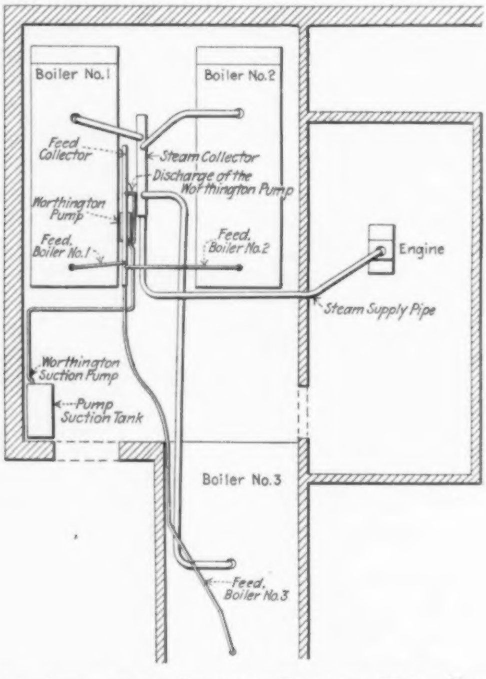

Fig. 7 Piping in the Bollinckx Tests for Water Hammer

ated velocities could be realized. The piping is shown in Fig. 7.

Three series of tests were carried out. In the first series the piping was as shown, but on the delivery piping a Westinghouse double-acting feed pipe was branched on. Several trials at various degrees of admission were made, but no water hammer action observed. In the second series of tests a pocket was made in the steam supply piping, having a volume of approximately 50 liters (13 gallons) and connected with boiler No. 3 (Fig. 7) by a special pipe. At the time when this was done the engine ran on steam supplied from the two other boilers, but arrangements for changing the connections were made beforehand. After the engine reached its normal speed, the steam gate valve to boiler No. 3 was suddenly opened so as to allow the water to fill completely the pocket in

the steam supply piping. Unlike what happened previously, the water, after passing through the cylinder, came out from the discharge pipe not in a continuous stream, but in successive jets. In a later test the steam gate valve was opened as rapidly as possible, so as to fill with water not only the entire steam supply piping, but also the cylinder lagging. The water passed through the cylinder and came out from the discharge pipe in spouts. The first mass of water was thrown at a distance of about 20 meters (65 ft.), and at the same time the discharge piping received a shock which produced a rupture of one of the joints and made a gap between the pipes of about 25 cm (say 10 in.). A few instants later another mass of water was discharged through the rupture in the piping. The engine was then stopped, the discharge piping put in order, and the same experiment repeated, the water always coming out from the discharge piping in successive jets. In none of these tests did any injury to the cylinder or joints occur, and it was observed that the size of the jets of water increased with the degree of admission. In the third series of tests it was desired to determine what would happen in the case of cylinder without lagging, to draw the conclusions for superheated steam engines. To do that, the piping was changed in a manner such that the steam supply pipe opened up direct into the admission steam valve chest, and all sorts of tests made. It was found that all the water which entered the cylinder of a steam engine during admission, ran out through the discharge piping during exhaust, without causing any trouble, whatever the amount of the water or load on the engine might be. This applies only to the case when the exhaust valves are placed at the bottom of the cylinder. The fact that the water runs out entirely is due to the fact that the admission rarely occupies more than 50 per cent of the stroke, while the exhaust nearly the entire stroke, and that the exhaust valves have usually a larger cross section than the admission valves. The difference of pressure between the interior of the cylinder and the boiler does not affect the above stated observation, since at the moment of the opening of the admission valve it was insignificant. The following general conclusions as to the origin of the water hammer phenomenon have been arrived at: (*a*) in single-cylinder engines a water hammer can occur only when the discharge piping has not been thoroughly blown through; the water then returns into the cylinder, especially when the engine runs at no-load, the pressure at the end of expansion being then below that of the discharge piping. To avoid water hammer, place at the bottom of the exhaust discharging into free air, a pocket of large capacity in which the water may accumulate, and make the same arrangement, by syphon or otherwise, that the water may run out of the pocket. That is what the Bollinckx Company has been doing for 25 years. (*b*) Single cylinder condensing engines: when the condenser is in tandem, the water can accumulate in the pipe between the condenser and the cylinder which acts as a pocket; if no precautions are taken, it can then be sucked up or driven into the cylinder and produce a hammer shock, such an accident happening at starting or at sudden throwing off of a large part of the load. The Bollinckx Company uses a steam loop continuously to blow out the pocket in this kind of installations. Usually, however, water hammer in this type of machinery is due to defective working of the air pump, but may

also be due to mistakes on the part of the engineer who, e.g., while slowing up the engine previous to stopping it, forgets to close the water injection cock to the condenser: in that case the output of the pump decreases because of the decrease in the speed of the engine while the water delivered to the condenser is still the same as before, and as a result, the water rises into the cylinder which, receiving no steam, acts as a pump. Precautions: to take care of purging the exhaust piping at its lowest point; provide a float vacuum-breaker actuated on by water tending to return to the cylinder in a manner such that this apparatus should destroy automatically the vacuum in the exhaust piping; when possible, provide an apparatus regulated by the governor and automatically decreasing the vacuum. It is a very useful thing in all cases to have a steam drier installed in the piping, in which case the additional advantages will be secured of lower steam consumption and elimination of washing of cylinder walls by the water in the steam and carrying away the lubricants. A number of diagrams is given in the original article.

WELDING OF STEAM BOILERS (*Die Schweissung von Dampfkesseln*, H. Jaeger. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 36, no. 14 and 15, pp. 161 and 179. 4 pp., 5 figs. *gp*). In 1912 in Prussia occurred three serious explosions of water tube boilers with headers which have attracted attention to the question as to the safety of this type of boilers generally and welded seams in boilers in particular. In the first case, in the central station of the Phoenix Company in Lierenfeld, exploded a boiler built by the Borsig Company in 1910, 412 qm. (4408 sq. ft.) heating surface and 15 atmospheres working pressure; the immediate cause of the accident being rupture of the flanged plate in the lower part of the header, 6.08 m (19.9 ft.) wide and 254 mm (10 in.) deep. The second explosion occurred in the rolling mill of the Menden and Schwerte Steel Works, with a new (built in 1911) Piedboeuf boiler having a header 3,575 m (11.7 ft.) wide by 300 mm (11.8 in.) deep, the immediate cause of the explosion being the loosening of the welded seam of the header plate which sprung open up to the corners. In the third explosion at the rolling mill Deutscher Kaiser in Dinslaken, a wall of the rear header became loose at the welded seam and rolled up to the second row of staybolts. The boiler was built in 1897 for a working pressure of 12 atmospheres, and was heated by exhaust gases. In all three cases the explosions were quite violent, the boilers being thrown at 165, 190 and 20 ft. respectively, and investigation showed that there were other causes besides possible weakness of the welded seam which in themselves might have been sufficient to account for the explosion. Thus in the Borsig boiler explosion it was found that the lower welded seam of the header was exposed to the direct action of the heating gases owing to insufficient protection by the boiler setting which had been defective for some time. In addition, boiler scale was washed out from the tubes into the front header where it caused imperfect cooling of the lower welded seam. Similar conditions have been found in the Menden-Schwerte explosion, while in the Dinslaken accident it was found that the lower row of staybolts was unusually far from the welded seam (224 mm or 8.9 in.), and in that row six staybolts were broken and several more cracks. Nevertheless, both the Prussian government and the manufacturers have organized a series of tests to determine

the strength of welded seams generally, as well as to answer the particular question as to the design of this type of boiler arising from the data given by these accidents. The Piedboeuf Company has made a series of tests with butt welded seams, and found that rupture occurred only at stresses many times exceeding those to which the seam would be subjected in boiler operation. The fracture showed a brilliant metal surface colored here and there by oxidized iron slags, the same as the surface of fracture of the exploded boiler. Since all possible care was exercised in the preparation of the tests seams and the welded pieces were sufficiently warm, it appears that with the present methods of work enclosure of oxidized slags cannot be prevented; and with thick sheets such as are used in water tube boilers, the specific pressure of the two welded surfaces against each other cannot be made large enough by hammering to force out from the joint the slags formed by the oxidizing welding flame. The following questions have also been investigated: (1) *the advisability of limiting the width and depth of headers, the former when there are two upper drums.* The use of two aggregates side by side would be about as economical in operation as one with two upper drums, while the handling of excessively large headers would be avoided; on the other hand, with the present hoisting apparatus, the latter does not present any serious

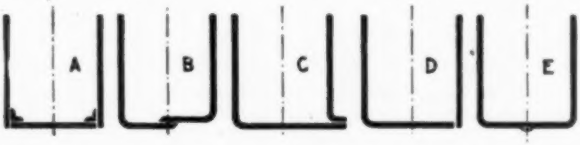

FIG. 8 VARIOUS METHODS OF BOILER SEAM WELDING

difficulties, while two units would be more expensive than one, and the total length of welded joints would be longer in the first case than in the second; there is therefore no reason for recommending a limitation of the width of headers. (2) The advisability of looking for a header design avoiding the use of butt welding entirely, or at least eliminating the lower welded seams of the headers lying towards the fire side. The following types were considered: (*a*) return to the riveting of the headers, either by connecting the side plate with the straight walls by means of angle irons (Fig. 8A), or (Fig. 8B), as in the Willmann boiler, by riveting together the front and rear walls, provided for this purpose with broad flanges, so that the rivet joint lies in the middle of the flanges serving as side plate: (*b*) by flanging both walls and making an external riveted seam (Fig. C); (*c*) by flanging the fire wall and butt welding to it the outer wall (Fig. D); (*d*) by flanging both walls and autogenously welding them in the middle as shown in Fig. E. The design shown in Fig. 8A is not advisable because it does not ensure complete safety of operation, and the row of rivets on the fire side forms a weak place in the boiler. The same applies to the design of Fig. B. A seam such as shown in Fig. C would be very expensive to make on account of the tall flanges of the inner walls, and in addition is not absolutely safe as to tightness, on account of there being only a single caulking edge. Some factories now contemplate the adoption of the design shown in Fig. D, which has the

advantage of not having the dangerous inner welding seam. (3) All experts agreed that the staybolts should be placed as near as possible to the welded joint, and not further than 75 mm (3 in.) from the wall. As to the advisability of reinforcing the staybolts and drilling their ends, opinions differ, but it appears advisable to do so, since in the Dinslaken boiler explosion it was found that six staybolts of the lower row had broken before the explosion, while several more started to crack. (4) The proposal to test the headers at a pressure double that of the operating did not meet with favor: considerably higher stresses are required to rupture the welded seam so that such a test would not really show much and it is difficult to make (difficult to make the header watertight), and the high pressure may start cracks in the header. The advisability of hammering up the seam with heavy hammers during the pressure tests was universally recognized as well as the possibility of injuring the seam by the use of too heavy hammers (sledges). Tests will be made to determine this point. (5) The author considers the annealing of the headers after the execution of welding work; even though the boring of holes and opening in the header relieves the metal to a certain extent from the stresses created by the welding process, this is not complete, and a certain amount of stresses remains; when annealed, some of the weaker places open up, while others can be recognized by the coloration of the metal sheet when cooled.

Mestre System Squirrel Cage Superheater for Tubular Boilers (*Le surchauffeur en cage d'écureuil système Mestre, pour chaudières tubulaires*, P. Lachasse. *Revue industrielle*, vol. 44, no. 9, p. 113, March 1, 1913. 3 pp., 18 figs. *d*). Description of the Mestre squirrel cage superheater for tubular boilers (for preliminary notice see *The Journal*, May 1913, p. 848). This superheater (Fig. 9A) consists essentially of: (*a*) header *B* placed transversely to the smoke box, and divided longitudinally into two chambers, *B'* and *B'''*; (*b*) six or seven vertical connectors *C* likewise divided into two compartments each, to communicate with the two chambers of the headers respectively; (*c*) superheating elements *D* located in large flue-tubes, in vertical rows, on the connectors. Wet steam from the boilers passes through pipe *A* to the first chamber *B'* of the header *B*, and is distributed from there to the front compartments *C'* of the connectors *C*, and thence to the superheating elements *D*, which convey the superheated steam to the rear compartments *C''* of the connectors, the second chamber *B'''* of the header and thence to the engine cylinders by the pipe *E*. The construction of the superheating elements is of particular interest. Each consists of a large central tube and eight or nine small tubes peripherally disposed around it in a definite manner, as described below. These outside pipes are bent in the rear part and joined to the large central tube by autogenous welding, the central pipe in its turn having a tip with a reduced diameter welded at the smoke stack end. The ends of the outside pipes are welded to the central pipe in three or four different planes in groups of two or three pipes and according to their number, each group consisting of two opposite welds or three at 120 deg. to each other. To permit the small tubes to follow the variations in length due to the inequality of their expansion as compared with that of the central tube, they are made either wave shaped (Fig. 9C) or helical (Fig. E).

The outside pipes are kept at a constant distance from the central tube by means of three groups of three to four stays, each stay connecting with the central pipe either two opposite outside pipes, or three outside pipes at 120 deg. to one another. The steam passes through the central tube going one way and returns through the outside tubes.

The advantages of the squirrel cage superheater are said to lie in the

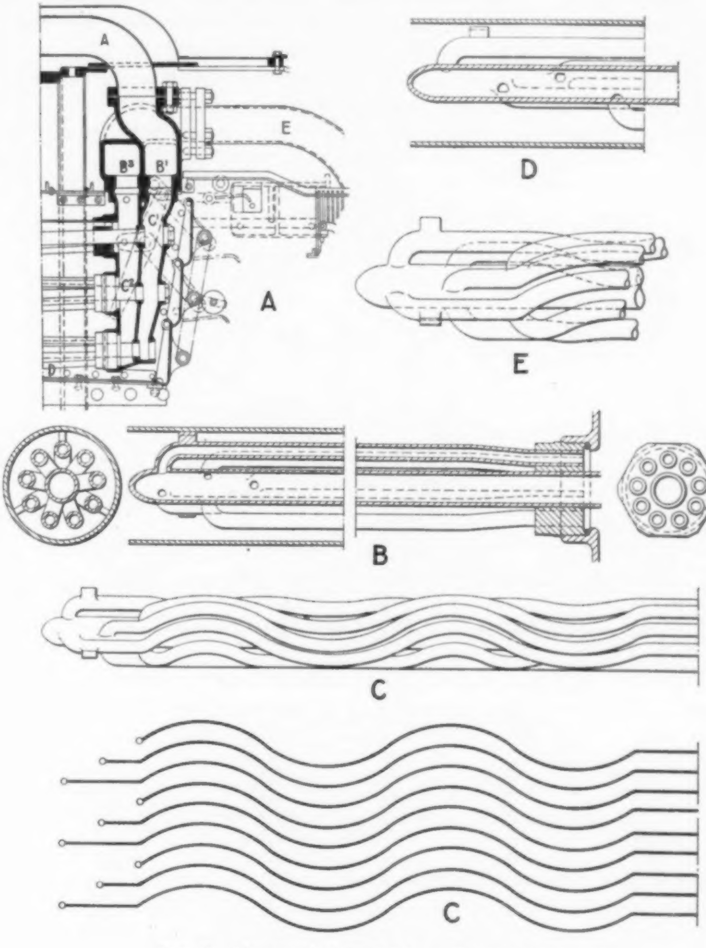

Fig. 9 Mestre Squirrel Cage Superheater

convenient distribution of the metal in the mass of gases passing through the respective flue. The wave or helical shape of the outside pipes produces an effective mixing of the gases which helps the exchange of heat between the gas and steam without impeding the draft in the flue, the latter being due to appropriate selection of the dimensions of the pipes.

Tests. Four of these superheaters have been installed by the Eastern

Railroad Company (France), three on high-speed, and one on a suburban locomotive. In the case of the first kind, the temperature of superheat, 1.7 km (say 1 mile) after starting, reached 270 deg. cent. (518 deg. fahr.), while under the same conditions it used to reach only 225 deg. cent. (437 deg. fahr.) with a Schmidt superheater (the locomotive was of the 4-6-0, compound, four cylinder type). The tests with the suburban locomotive have shown, that contrary to the general belief, superheating, when used with this kind of apparatus, may be efficient for service with frequent stops. This is due mainly to the great sensitiveness of the squirrel cage superheater, the pyrometer needle showing marked rise of temperature 15 seconds after the opening of the throttle, so that, with two stations 1200 m (0.75 miles) distant from one another, the temperature fell to 290

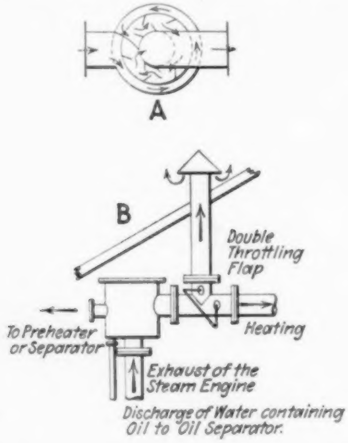

FIG. 10 HEINE COMBINED CENTRIFUGAL AND BAFFLE SEPARATOR

deg. cent. (554 deg. fahr.) during a 45-seconds stop at the first station, but rose to 342 deg. cent. (645.8 deg. fahr.) by the time the throttle was closed at the entrance to the second station. The Schmidt superheater gave, under the same conditions, from 40 to 50 deg. cent. (72 to 90 deg. fahr.) less superheat. There have been no breaks or leaks in the joint with the squirrel cage superheaters. No complete data of tests are given in the original article.

HEINE SEPARATORS (*Die Heine-Abscheider, Der praktische Maschinen-Konstrukteur*, vol. 46, no. 9, p. 14 (Triebwerke), April 24, 1913. 1 p., 6 figs. *d*). Description of the Heine separators which are *combined centrifugal and baffle separators*. The gas to be cleaned is carried around one or more times in circles, and deposits its liquid constituents on blades of special shape provided for this purpose. A schematic view of this separator is shown in Fig. 10A, Fig. B showing it as applied to oil separation from steam. This is used also for *drying steam*, or eliminating from it water particles. Similar apparatus are constructed for oil separation from compressed air handled by piston compressors. The original article contains tables giving data as to dimensions and weights of various kinds of such separators.

Measurement of Water in Factories to Determine the Self-Cost of Steam or to Test the Boilers (*Mesure de l'eau dans les usines pour déterminer le prix de revient de la vapeur ou pour les essais de chaudières*, J. Izart. *La Technique moderne*, vol. 6, no. 8, p. 314, April 15, 1913. 1½ pp., 8 figs. *d*). Description of various devices for measuring the feedwater of boilers. The author rejects absolutely all closed water meters, both speed meters (meters with blades) and volumetric (piston meters, etc.), although he considers the latter somewhat more reliable. Only the open meter of the *tipping type* should be used, as they are simple in operation, easy to check, and reliable. The Dégrémont meter (Fig. 11A) consists essentially of a drum 1 divided into three chambers, rotatable about an axis, and making one piece with a three-branch star-shaped body 2. Referring to the figure, the chamber to the left of the drum is being filled, the drum being held in position by the roll 3 and set screw (not shown). The roll 3 is at the end of a lever with a counterweight rotatable about an axis; when the

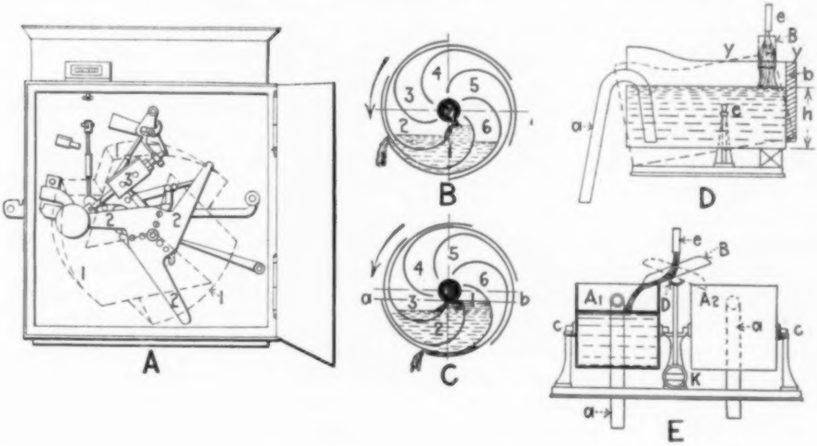

Fig. 11 Boiler Feedwater Meters

amount of water in a compartment reaches a certain predetermined weight, the ray of the star makes the lever tilt by lifting the counterweight, in consequence of which the drum, no longer kept in place by the set screw, starts to rotate, pours out the water from one compartment, and offers the next to the stream of water pouring in, thus recommencing the entire operation. While the drum is tilting, the orifice of the pipe admitting the water is closed by a special stopper.

The Hans Reisert drum meter (Fig. 11B and C) consists essentially of a series of troughs rotating about a central axis through which water is admitted; in filling successively, these troughs cause the rotation of the drum, a special device recording the number of revolutions; as it is the weight of the water that causes the troughs to rotate, the meter actually records the weight of the water. In B water from 6 is flowing out, 1 is full and the overflow is filling 2 which, in filling while 6 is emptying, causes the drum to rotate in the direction of the arrow. In Fig. C is shown a moment of equilibrium: the internal and external edges of the trough 1 pass through the same horizontal line *ab*, and no water flows out;

but since the trough 3 continues to fill, a moment will soon come when the outer edge will be below the inner one, and 1 will begin to empty.

The Leitner meter is shown in Fig. 11D: it consists of two tanks A_1 and A_2 of equal size, and arranged so that they can tilt over the knife edge e; one of the walls of each tank is provided with a syphon a and the opposite wall with a counterweight b of such weight as to balance a weight of water corresponding to the height of level h. As soon as the water exceeds this level the tank tilts and the syphon empties the water, while a special device records the number of tilts. To this same class of meters, the Wilcox meter, fully described in the article, also belongs.

Strength of Materials and Materials of Construction

Experiments on Rusting of Iron in Mortar and Brickwork (*Versuche über das Rosten von Eisen in Mörtel und Mauerwerk, Ausschuss für Eisenbeton*, vol. 22, Berlin, 1913, through *Dinglers polytechnisches Journal*, vol. 328, no. 16, p. 253, April 19, 1913. ½ p. *e*). Resumé of the tests made at the Laboratory for Testing Materials at Gross-Lichterfelde-West, 1907 to 1913, under the direction of Professor Gary. Portland cement mortar, slag portland cement mortar, common mortar, and plaster were the materials used; reinforcing elements were of flat iron, 5.07 cm in section (probably 5.07 qcm, or 0.77 sq. in.), and round iron, 3.5 cm (1.38 in.) and 1.0 cm (0.38 in.) in diameter, set so that pieces stuck out of the mortar, for the grips in sliding resistance tests. The test-pieces were ¾, 2 and 5 years old, and had been kept in free air, sweet water, alternately air and sweet water, sea water, bog water and moist sand. The pieces in common and plaster mortar showed weathering even at the beginning of the tests. In all cases rusting began at the iron ends sticking out of the mortar, which must be remembered in considering these test data, since in usual reinforced concrete constructions the iron is fully embedded in concrete. The iron elements were either clear of skin due to rolling, or rusted, coated by red lead, tar or zinc. The iron pieces free from all covering have suffered most from rusting, while a coat of red lead proved to be the best form of protection; the sliding resistance of the red lead coated iron elements proved to be slight at first, but increased with time. Sea water did not appear to attack iron in mortar, probably because protection was afforded by the formation of a porous covering through displacement of lime in the mortar by magnesia from sea water. The original contains a full description of the testing apparatus and methods, as well as complete data of tests, mostly in tabular form.

See also Mechanics for Article on Young's Modulus.

Thermodynamics

New Tables and Diagrams for Sulphurous Acid (*Neue Tabellen und Diagramme für schweflige Säure*, Dr. Hýbl. *Zeits. für die gesamte Kälte-Industrie*, vol. 20, no. 4, p. 65, April 1913. 6 pp., 10 figs. *tA*). From the Callendar equation the author derived the following simple equation of state for sulphurous acid:

$$v-v'=\frac{13.24T}{P}-0.016\left(\frac{273}{T}\right)^4 \qquad [1]$$

where v' is the specific volume of the liquid, within the range used in refrigerating engineering treated as a constant equal to $v'=0.0007$. The same can be expressed in other ways, e. g., in the form of the Tumlirz equation, such as

$$v=\frac{13.24T}{P}-0.01 \qquad [2]$$

or or that of van der Waals:

$$P=\frac{13.24T}{v-0.006}-\frac{61}{v^2} \qquad [3]$$

The Tumlirz form has a very limited range of application, because, although good for saturated vapor, it gives too small specific volume values for superheated vapor, which is due to the constant used in the equation being too large. The van der Waals equation gives values which agree with the latest experimental data, but is not convenient for practical use because it contains the expression for the specific volume in the third power.

For the functional relation of pressure, temperature and specific volume for

TABLE 1 COMPARISON OF VALUES OBTAINED FROM VARIOUS EQUATIONS FOR VOLUME OF SATURATED SULPHUROUS ACID VAPOR WITH EXPERIMENTAL VALUES

Temperature, Deg. Cent.	Pressure, kg/qcm	Equations			Mollier	Cailletet	Zeuner
		[1]	[2]	[3]			
−30	0.392	0.795	0.811	0.808	.....	0.822	0.794
−20	0.657	0.488	0.500	0.497	.....	0.513	0.503
−10	1.039	0.317	0.325	0.322	.....	0.330	0.329
0	1.578	0.213	0.219	0.216	0.213	0.223	0.221
10	2.321	0.148	0.151	0.150	0.148	0.152	0.152
20	3.320	0.105	0.107	0.106	0.106	0.107	0.107
30	4.635	0.076	0.077	0.076	0.077	0.076	0.076
40	6.335	0.056	0.056	0.056	0.57	0.055	0.055

saturated steam the author uses the values of Cailletet and Mathias, with the last decimal changed, and compares the values obtained from the three above equations with those in the steam tables of Zeuner, Cailletet and Mathias, and Mollier (Table 1). At temperatures above 0 deg. cent. the specific volumes of Mollier are larger, at temperatures below 0 deg. smaller than those of equation [1]; all the other values show the same behavior, viz., first increase with increasing temperature, and then fall with decreasing.

Next comes the behavior of superheated sulphurous acid vapor, for which, with $t=100$ deg. cent. as a basis, the specific volumes indicated in Table 2 are obtained from the three equations, the Tumlirz equation [2] giving the smallest values, while [1] and [3] give practically identical values, the differences in the practically exploited region of temperatures both for the saturated and superheated vapor being less than one per cent either way.

From equation of state [1] and the general heat equation $di=Tds+Adp$, the following equations are derived:

Total heat content: $i=c_p^0 t-1.878\cdot10^{-4}\left(\frac{273}{T}\right)^4 P+1.64\cdot10^{-6}P+y$

Entropy: $S = c_p^o \ln T - 0.03108 \ln P - 1.5 \cdot 10^{-4}\left(\frac{273}{T}\right)^4 \frac{P}{T} x$

Specific heat at constant pressure: $c_p = c_p^o + 7.51 \cdot 10^{-4}\left(\frac{273}{T}\right)^4 \frac{P}{T}$

where c_p^o is the limiting value of specific heat. According to the latest determinations it increases somewhat with temperature, but so little that for all practical purposes it may be assumed to be constant and equal to 0.32. The last equation indicates that the specific heat c_p increases with pressure, but decreases when the temperature increases, which fully agrees with the latest experimental determinations. The values of x and y are determined in the usual manner from an equation showing the law of variation of the specific heat of the liquid, in this case the Cailletet equation: $c = 0.32 + 0.001172t$, by determining the total hea

TABLE 2 COMPARISON OF VALUES OBTAINED FROM VARIOUS SOURCES FOR VOLUME OF SUPERHEATED SULPHUROUS ACID VAPOR

Pressure, kg/qcm	Equations		
	[1]	[2]	[3]
1	0.489	0.484	0.488
2	0.242	0.237	0.241
3	0.159	0.155	0.158
4	0.119	0.115	0.118
5	0.093	0.089	0.092
6	0.077	0.072	0.076
7	0.065	0.061	0.064
8	0.056	0.052	0.055

content and entropy for some two pressures, and solving the equations so obtained for x and y. It is found that as the temperature rises, x increases and y decreases; y in the expression for the heat content decreases also with the increase of pressure.

From the total heat content is derived the heat of evaporation: $r = i - q$. The external heat of evaporation can be derived either from equation $\psi = AP\ (v - v')$, or from the equation of state:

$$AP(v - v') = 0.03108\ T - 3.75 \cdot 10^{-4} P \left(\frac{273}{T}\right)^4$$

and the inner heat of evaporation from equation

$$\rho = r - AP\ (v - v')$$

In Fig. 12 are drawn the curves of heat of evaporation according to Cailletet, Zeuner, Mollier and equation [1], showing that at low pressures the Zeuner and Cailletet values are the largest, and at high pressures the smallest, while the values from equation [1] lie between them and the Mollier values nearly throughout. On the basis of his new steam tables the author has constructed a heat entropy diagram TS for sulphurous acid, in connection with which *cp.* Table 3. In that diagram the curves of constant temperature are represented by straight

TABLE 3 SATURATED SULPHUROUS ACID VAPOR TABLE

Temperature, Deg. Cent.	Pressure, Atm. Abs.	Volume, cbm/kg	Spec. Weight, kg/cbm	Heat Content		Heat of Evaporation			Entropy		r/T	Specific Heat
t	p	v	γ	Liquid q	Vapor i	Total r	Internal	External	of Liquid S'	of Vapor S		c_p
−30	0.392	0.795	1.258	−9.07	82.73	91.80	84.50	7.31	−0.0352	0.3426	0.3778	0.339
−25	0.512	0.617	1.621	−7.63	83.48	91.11	83.70	7.41	−0.0293	0.3381	0.3674	0.343
−20	0.657	0.488	2.049	−6.17	84.23	90.40	82.88	7.52	−0.0234	0.3339	0.3573	0.346
−15	0.831	0.391	2.558	−4.67	84.97	89.64	82.02	7.62	−0.0175	0.3299	0.3474	0.350
−10	1.039	0.317	3.155	−3.14	85.70	88.84	81.13	7.71	−0.0117	0.3261	0.3378	0.355
− 5	1.286	0.259	3.861	−1.59	86.41	88.00	80.21	7.79	−0.0059	0.3225	0.3284	0.359
0	1.578	0.213	4.695	0	87.10	87.10	79.23	7.87	0	0.3190	0.3190	0.363
5	1.921	0.177	5.650	1.61	87.77	86.16	78.22	7.94	0.0059	0.3158	0.3099	0.368
10	2.321	0.148	6.757	3.26	88.41	85.15	77.15	8.00	0.0117	0.3126	0.3009	0.374
15	2.785	0.124	8.065	4.93	89.01	84.08	76.03	8.05	0.0175	0.3094	0.2919	0.379
20	3.320	0.105	9.524	6.63	89.57	82.94	74.84	8.10	0.0234	0.3065	0.2831	0.384
25	3.934	0.089	11.236	8.37	90.08	81.71	73.56	8.15	0.0293	0.3035	0.2742	0.389
30	4.635	0.076	13.158	10.13	90.52	80.39	72.20	8.19	0.0352	0.3005	0.2653	0.395
35	5.432	0.065	15.385	11.92	90.86	78.94	70.72	8.22	0.0410	0.2973	0.2563	0.401
40	6.335	0.056	17.857	13.74	91.08	77.34	69.09	8.25	0.0469	0.2940	0.2471	0.408

lines parallel to the axis of entropy. The curves of constant entropy (adiabatic curves) are represented by straight lines parallel to the axis of temperatures; the curve of constant pressure within the region of wet vapor by straight lines parallel to the axis of entropy, which could be done because, at constant pressure, the variation of state is identical with that of temperature. Within the region of superheat, however, they are logarithmic curves, because at constant pressure the amount of heat brought in is $dQ = c_p dT$, and consequently the increase of entropy, at constant pressure and assumed average constant specific heat c_p, is for variable superheat, between the initial and final state:

$$\int \frac{dQ}{T} = c_p \int_T^{T_1} \frac{dT}{T} = c_p \ln \frac{T_1}{T}$$

These curves are drawn smooth. The curves for constant total heat i are drawn in broken line, while the curves for constant specific volume v are dotted. In the

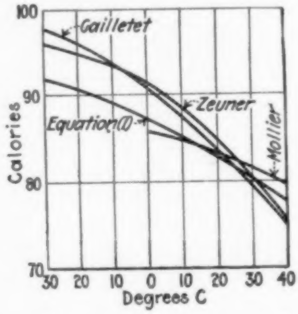

Fig. 12 Heat of Evaporation Curves for Sulphurous Acid

region of wet vapor the specific volume for various pressures may be derived from the equation $v = v' + xw$, and then the entropy from

$$S = \sigma + x\frac{r}{T}.$$

In the region of superheat recourse must be had to the equation of state for superheated vapor, from which, for various pressures, first the temperatures T_1 and then the entropies are calculated.

The curves for constant specific quantity of steam x are obtained by calculating from equation

$$S = \sigma_x + x\frac{r_x}{T_x}$$

the entropy for various pressures, but the same amounts of steam. The construction of these curves is simple: all that is required is to divide into equal ratios the sections r/T.

In conclusion the author gives two examples showing the use of this entropy diagram.

Miscellanea

Profit Sharing (*La participation aux bénéfices*, M. Bellom. *La Technique moderne*, vol. 6, no. 9, p. 329, May 1, 1913. 5½ pp. *cd*). Brief description and analysis of various methods of profit sharing in modern industrial establishments,

with reference mainly to the practice of Continental Europe. The material is taken from the most part from the publications of the French Society for the Practical Study of Profit Sharing by Employees.

Reply to a Criticism of the Taylor System (*Reponse a une critique du système Taylor*, H. Le Chatelier. *Le Génie Civil*, vol. 62, no. 26, p. 514, April 26, 1913. 1 p. *c*). The author, a well-known metallurgist and member of the French Academy of Sciences, disagrees with Admiral J. Edwards' criticism of the Taylor system. To the objection that the installation of the Taylor system is costly, he replies that a modern battleship is more costly than a pirogue of a savage, and still battleships and not dug-outs are built. The Taylor system is costly, but its advantages are great. In the admiral's statement that "in naval arsenals quality and not quantity must be the main standard of production," he sees a contempt of the problem of cost common to government officials in all countries, a point of view which can be approved neither with regard to the taxpayer's rights, nor that of military efficiency. With the same amount of money, and a reduction of cost of 10 per cent, eleven battleships can be built where only ten were possible without the reduction. The Taylor system does not lower the quality of production, since a better organization is conducive both to improvement in quality and increase of volume of production. In France the shops which have adopted the Taylor system are unquestionably in the first rank as far as the quality of their products is concerned. The next objection to the Taylor system is that with its introduction salaries do not increase as rapidly as production. The author says that there is no reason why they should; no extra efforts or longer hours are demanded from the workmen, and in addition the costly organization connected with the introduction of the system has to be paid for; the 25 to 75 per cent increase of salaries which usually follows the introduction of the new system is really more than what the workmen are entitled to. The author also fails to see the force of Admiral Edwards' objection shared by him with some labor leaders as to the use of the stop-watch. No workman objects to being timed by a stop-watch when running a race or in a bicycle competition, so why should he do so when at work? The Admiral says further that the Taylor system involves such a strain on the part of the workman as to be harmful to his health. If it does, that only means that the system applied has nothing to do with Taylor whose system has for its object to increase the production without increasing the effort on the part of the workman. That some workmen may overwork under the Taylor system, just as they do now, is possible, but has nothing to do with the principles of scientific management, except in showing their unsatisfactory application. Can one deny that Mr. Gilbreth with his arrangement of placing bricks on movable scaffolds, so as to dispense with the constant stooping of the workman to pick up bricks, lessens his effort?

There are, however, two difficulties in connection with the Taylor system which the author recognizes: (*a*) to have in the shops the perfect discipline essential to the operation of this system. In ordinary shop management some lack of discipline is not as important as in an organization where a large outlay is made for planning, and will become a dead expense unless this planning is followed out; and (*b*) to find men willing and able to carry this system into practice, engineers with a scientific spirit, knowledge of both the theory of their trade and the practice of the manual operations by which it is carried on, and at the same time with that knowledge of the psychology of the workman which would allow

them to get the men's confidence in the first ten words of a conversation. The technical schools give a training diametrically opposite to those requirements, by laying the main emphasis on scientific methods and by but little appreciating the value of actual industrial processes.

IMPROVED VACUUM GAGE IN TECHNICALLY APPLICABLE FORM (*Ein verbessertes Kompressionsvakuummeter in technisch brauchbarer Ausführung*, B. Thieme. *Elektrotechnische Zeitschrift*, vol. 34, no. 17, p. 469, April 24, 1913. 1 p., 5 figs. *d*). Description of the MacLeod vacuum gage as improved by Reiff for the measurement of high vacua such as occur in incandescent lamps. The technical applicability of the apparatus lies in the fact that, although nearly 4 ft. long, it has no movable glass parts, and can therefore be handled with comparative ease.

Supplementary References

STRESSES PRODUCED IN MATERIALS BY RIVETING (*The Journal*, February 1913, p. 339). Cp. also *The Compressive Forces Required to Form Rivet Heads*, by Earl D. Hay and Wm. L. Edwards in *The Rose Technic*, March 1913, p. 173.

TESTS OF AUTOGENOUS WELDING (*The Journal*, December 1912, p. 2090). For another account of the same series of tests see *Essais sur les soudures autogènes in Revue de Métallurgie*, vol. 10, no. 3, P. (Extraits) 78, March 1913, abstracted from *Bulletin de l'Association Lyonnaise des propriétaires d'appareils à vapeur*, XXXV, 37.

RINCKER-WOLTER GAS PRODUCERS (*The Journal*, November 1912, p. 1881). Cp. *Carbureting with Tar*, *The American Gas Light Journal*, vol. 98, no. 13, p. 201, March 31, 1913.

ODDIE-SIMPLEX PUMPS (*The Journal*, May 1913, p. 902). For description of same cp. *Revue industrielle*, vol. 44, no. 2081/16, p. 217, April 19, 1913.

ON THE REALIZATION OF HIGH ANGULAR SPEEDS (*The Journal*, March and May 1913, pp. 533 and 893). Cp. paper by the same author, M. Leblanc, *Machines rotatives à très grande vitesse in Mémoires de la Société des Ingénieurs Civils de France*, February 1913, p. 171.

THE EQUIVALENT OPENING OF A VENTILATING SYSTEM (*The Journal*, April 1913, p. 692). Cp. an abstract of the same article in *The Engineering Review* (London), vol. 26, no. 10, p. 366, April 15, 1913. This abstract contains the curves of fan efficiencies omitted in the abstract in The Journal.

STORAGE OF INFLAMMABLE LIQUIDS, MARTINI AND HÜNEKE SYSTEM (*The Journal*, February 1912, p. 294). Full description of this system in *Braunkohle*, vol. 12, no. 3, p. 35, April 18, 1913.

MEETINGS

BOSTON MEETING, APRIL 25

A meeting of the Boston Society of Civil Engineers, the American Institute of Electrical Engineers, and of The American Society of Mechanical Engineers, under the auspices of the Institute, was held in the Lowell Building of the Massachusetts Institute of Technology, on Friday evening, April 25. A paper on the Delivery and Handling of Freight at the Boston Freight Terminals, by Dr. Harold Pender, H. F. Thompson and C. P. Eldred, was presented. This paper is based on a series of studies of the conditions prevailing at the local freight terminals, with reference to possible improvements. A number of slides were presented showing the distribution of business throughout the day, bringing out strikingly the pronounced "peaks," at inbound houses in the morning and outbound houses in the later afternoon, and illustrating the resulting congestion. The movement of teams of various classes was analyzed with respect to time spent in yards, at warehouses and on the street, and the proportion of time in the yard spent in various ways, such as inquiry, searching, loading, etc., was investigated. The increased efficiency obtained by certain changes introduced as a result of these studies was also shown.

A number of railroad men were present at the meeting and an animated discussion followed the presentation of the paper.

CHICAGO MEETING

The members of the Chicago Section held a meeting at the City Club on May 7. A dinner preceded the business meeting, at which about 77 members and guests were in attendance. P. M. Chamberlain, chairman, called the meeting to order, announcing that its purpose was a better mutual acquaintanceship among the membership, the social features being more in evidence than at previous gatherings. A committee to care for the work of the coming season was elected, consisting of P. P. Bird, C. R. Birdsey, Wm. B. Jackson, A. W. Moseley and C. W. Naylor.

The chairman then introduced Captain Robert W. Hunt, Past-President of the Society, who talked on the Society's Founders. He dwelt most entertainingly on the early years of the Society's life and told about the men who had to do with its organization, relating many interesting incidents in connection with its formation. Captain Hunt's personal acquaintance with all of those who were active in the Society's affairs during its first years gave his remarks a personal quality which added to their interest.

The next speaker, Philetus W. Gates, president of the Hanna Engineer-

ing Works, and a former vice-president of the Society, told, under the title of Early Machine Shops of Chicago, of the experiences of his father and himself in the early days of machine shop practice in that city. His father started the first machine shop there and Mr. Gates' remarks were enhanced by personal experience with conditions.

George M. Brill, a former vice-president of the Society, then gave an account of a trip to Brazil which he had recently made, describing the immense natural resources of South America and the cities which he had visited.

STUDENT BRANCHES

COLUMBIA UNIVERSITY

The annual business meeting for the election of officers of the Mechanical Engineering Society of Columbia University was held May 9 and the following were elected: Frank B. Schmidt, chairman; William Harvey, vice-chairman; W. L. Garrison, treasurer; Harold F. Allen, secretary.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On April 13 the Mechanical Engineering Society of Massachusetts Institute of Technology held their annual banquet at the Boston City Club. The officers elected for the coming year were as follows: W. H. Treat, chairman; W. E. Lucas, vice-chairman; L. L. Downing, secretary; F. P. Karns, treasurer, and R. L. Parsell, F. G. Burinton, W. H. Wilkins, governing committee. The rest of the evening was given over to a general jollification.

On April 25 J. F. D. McDonald of the International Engineering Company addressed the society on Modern Boiler Making Practice. His lecture was illustrated with lantern slides.

On May 3 Charles T. Main, Mem.Am.Soc.M.E., spoke on The New Power Plant of the Pacific Mills at Lawrence, Mass.

On May 5 Frank W. Reynolds, Mem.Am.Soc.M.E., spoke on the subject of The Modern Cotton Mill. The lecture was illustrated with many lantern slides.

F. B. Perry, Mem.Am.Soc.M.E., spoke on The Individual Drive, on May 9. The use of over one hundred lantern slides and Mr. Perry's long experience in the mill department of the General Electric Company made the lecture a particularly valuable one.

OHIO STATE UNIVERSITY

The cause of education has been advanced by the magnificent way in which the students of the Ohio State University met the emergency conditions during the recent flood. Both public and private acknowledgments have been received, and laboratory proof furnished that public education is a good investment for the state, by the intelligence, leadership and efficiency displayed by the men students in building boats, rescuing people from second-story windows, transporting food, clothing and medicines, rescuing property, shoveling mud after the subsidence of the water and putting life, good cheer, and hopefulness and spirit into many people.

PENNSYLVANIA STATE COLLEGE

The motive power section of the Pennsylvania State College Student Branch was addressed by C. E. Barba, assistant engineer for the Pennsylvania Railroad, on April 18. The subject was Railroad Wrecks, their Causes and Prevention. The speaker is in charge of the design of rolling stock for the Pennsylvania Railroad at Altoona, Pa., and he has for many years made a study of this subject with the idea of correcting car and truck design to prevent accidents. He thought the matter of car inspection quite as important as the design in the prevention of wrecks.

John Calder, Mem.Am.Soc.M.E., addressed the faculty and students on April 28, at both a morning and afternoon session, on the subject of Business Organization.

At a meeting held May 6 the following officers were chosen for the coming year: H. L. Swift, chairman; C. F. Kennedy, vice-chairman; Homer L. Hughes, secretary; R. B. Rudy, treasurer. Following the election papers on the Diesel Engine by A. L. Foell, and on Steam Turbines by H. L. Hughes, were read. Each discussed the cost of installation and operation of the respective prime movers as compared with other machines of the same class.

UNIVERSITY OF CINCINNATI

On April 18, Parker H. Kemble, Mem.Am.Soc.M.E., delivered an illustrated lecture on The Development of the Automobile from 1600 to 1896. His lecture was splendidly illustrated with a very complete set of lantern slides.

UNIVERSITY OF ILLINOIS

At a meeting of the Student Branch of the University of Illinois on April 18, Mr. Dumonosque, of the mechanical engineering department of the university, gave a paper on the Production of Oil Gas. The talk covered the development of the present apparatus used in the process, and the theory underlying it. A general discussion followed in which the cost of production, heat value and the composition of the gas was brought out.

On May 2, Prof. G. A. Goodenough, Mem.Am.Soc.M.E., gave an account of What Mechanical Engineers Do. A discussion of the nature of the positions now filled by the university's graduates followed the address.

UNIVERSITY OF NEBRASKA

On May 6 the officers for the coming year were elected; they are as follows: A. A. Luebs, chairman; George W. Nigh, secretary; A. V. Larson, treasurer; C. A. Hauptman, reporter.

YALE UNIVERSITY

On April 23 the mechanical and electrical engineering students held a joint meeting at which W. L. Morse, terminal engineer of the New York Central Railroad, delivered an interesting lecture on the Grand Central Terminal Improvements in New York. Lantern slides were used to illustrate the paper.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

ABHANDLUNGEN UND BERICHTE ÜBER TECHNISCHES SCHULWESEN. vol. 1–4. *Berlin, 1910–1912.* Gift of Deutschen Ausschusz für Technisches Schulwesen.

DIE ABHITZKESSEL, F. Peter. *Halle a. S., 1913.*

AIR COMPRESSION AND TRANSMISSION, H. J. Thorkelson. *New York, McGraw-Hill Book Co., 1913.*

This work is based on lectures delivered by the author to his classes at the University of Wisconsin. It gives adequate theoretical treatment, and a description of the most modern machinery applied to ventilation, power transmission and refrigeration.

BEITRAG ZUR BERECHNUNG DER KREUZWEISE BEWEHRTEN EISENBETONPLATTEN UND DEREN AUFNAHMETRÄGER, A. Danusso. *Berlin, 1913.*

DIE BLECHBEARBEITUNGS-TECHNIK, F. Georgi and A. Schubert. *Leipzig, 1913.*

CIRCULATION OF WATER IN STEAM BOILERS. From a Lecture by Geo. H. Babcock, delivered at Cornell University, February 1890. *New York, 1912.* Gift of E. T. Copeland Co.

DETROIT RIVER TUNNEL, ALTERNATE DESIGN FOR, BY THE MCBEAN METHOD. 1 sheet. Gift of D. D. McBean.

DEUTSCHER AUSSCHUSS FÜR EISENBETON. pt. 5–8, 10–11. *Berlin, 1910–1911.*

ELEKTRISCH BETRIEBENE AUFZÜGE, IHR WESEN, ANLAGE UND BETRIEB, P. Schwehm. *Hannover, 1901.*

DIE FÖRDERTECHNIK. vols. 2–4, 1909–1911. *Berlin, 1909–1911.*

ENGINEERING THERMODYNAMICS, C. E. Lucke. *New York, McGraw-Hill Book Co.* 1912.

The whole book is divided into three parts. The first three chapters deal with work without any particular reference to heat, the second two with heat, without any particular reference to work, and the last with the relation between heat and work. Of the first three the second chapter deals with the determination of the work done in compressor cylinders and the third, the available work in engine cylinders, in terms of all the different variables that may determine the work for given dimensions of cylinders or for given quantities of fluid. Chapter five treats heating by combustion, fuels, furnaces, gas producers and steam boilers, gas engines and refrigerating machinery being left to the last chapter. A large number of tables and diagrams are given in the text, which makes the book a valuable source of reference. A somewhat novel feature of the book is that nearly all formulae are written out in words in addition to or instead of expressing them in symbols. This saves a great deal of time and labor in hunting up the meaning of symbols by one who is not familiar with the notification adopted in the text; it is also a help to many engineers who do not possess the ability to visualize the physical meaning of an engineering formula expressed analytically, and have to have it translated to them in plain language before they can see what it is about. As Professor Perry said about twenty-five years ago, there are many engineers who

skip a page when they see on it a sign of integration, and for them (and they may be very good engineers otherwise) Professor Lucke's system of writing out the formulae, especially the somewhat complicated thermodynamic relations, will be certainly welcome. The book contains a large number of examples, both worked out in full and left in the state of problems to be solved by the reader.

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EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. Notices are not repeated except upon special request. Names and records, however, are kept on the current office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month. The list of "men available" is made up from members of the Society. Further information will be sent upon application.

POSITIONS AVAILABLE

506 Superintendent of large experience in automobile and Diesel engine construction. Location Indiana.

507 Office manager with mechanical and commercial training. Location Indiana.

509 Assistant to works manager, able to help on design of special devices to plan piping lines, building changes, requisition materials required, carry on investigation of proposed machinery, furnace and other equipment. State experience, age, whether married or single, salary wanted and references. Location Massachusetts.

510 Man with broad experience in the design of high-grade steam power stations. Location Boston.

511 Established firm of efficiency engineers desire to add to their staff, two or three young technical graduates with about one or two years' business experience since leaving college.

514 Industrial engineer desires capable rate-setter.

515 Supervising engineer for management and development of properties. Technical graduate, with ability to handle men, and experienced in operation and repair of all kinds of boilers, elevators, plant work, etc.

MEN AVAILABLE

110 Member, aged 35, graduate of Massachusetts Institute of Technology, three years in charge of work in mechanical engineering in the post graduate department of the United States Naval Academy, wishes to make another engagement after July 1. Thoroughly experienced in engineering, testing and experimental work; broad commercial experience. Fully competent to develop engineering department in new school or to broaden and revise work of an existing department along most modern lines.

111 Junior member, 30 years of age, mechanical engineer, technical education, 10 years' practical experience, in design, construction, operation, maintenance and reorganization of mill, factory, and other manufacturing properties. Wide experience in the superintendance of central power stations, factory extension, mill and reinforced concrete construction work.

Desires position of mechanical superintendent or master mechanic. Particularly experienced in practical efficiency work. At present employed.

112 Mechanical engineer, Member, 31, technical training, now in charge of drafting room and planning department of large manufacturing and repair shops abroad, desires position as assistant manager or efficiency engineer. Can coöperate with and handle men.

113 Junior, 27, married. Now employed but desires to locate with a live, progressive Eastern concern, opportunities for advancement. Technical graduate: machine shop and drafting room experience: executive ability. Full particulars upon application. Best of references furnished.

114 Professor of mechanical engineering in charge of department in a state university desires to change to similar position or to practical work.

115 Technical graduate, age 30 years. Five years' experience in charge of power plant economy and testing work, expert on operation of stokers, boilers, and surface condensers. Familiar with all kinds of power plant apparatus, would like position with company manufacturing condensers, consulting engineer doing power plant business, or as superintendent or assistant superintendent of power for lighting and power company. Best references. Salary $225 per month.

116 Graduate engineer with excellent experience along mechanical and electrical lines with consulting, manufacturing and selling concerns desires permanent position in or near New York. Age 36, at present employed in an executive sales position, but desires to change for a better future and more permanent work.

117 Technical graduate with shop, testing, designing and sales experience in internal-combustion engine line, desires to connect with gas engine concern, or teaching engineering subjects.

118 Technical graduate, age 37, practical mechanic with 15 years' experience in executive and designing capacity in various lines, desires position as superintendent or mechanical engineer.

119 Mechanical graduate, age 35, general experience, mechanical and electrical engineering: matters relating to construction, plant maintenance, machinery, shop and laboratory inspections: engineering specifications, contracts, valuations.

120 Mechanical engineer, operation, maintenance and construction, government, railroad and factory experience. Recently plant engineer.

121 Member, graduate mechanical engineer, open to engagement for teaching mechanical engineering. Six years' experience in charge of the department in a state university.

122 Junior member; married, desires position as superintendent or business manager, preferably with an educational or medical institution. Seven years in present position as assistant manager of an important New York institution. Experienced in employing, organizing, purchasing, planning and supervision of building construction. Also five years of practical engineering experience. Salary dependent upon opportunity. Very best of references.

123 Member, technical graduate, 18 years' experience, at liberty after July 1. Thoroughly conversant with modern machine tools and methods and foundry practice both grey and malleable iron. Last ten years has

systematized shops and processes, installed cost production, routing, piece and premium payment systems with marked reductions in cost. Wishes to obtain position with large concern as general efficiency man, works manager or general superintendent.

124 Student member, age 27, will graduate from Cornell in June 1913, seven years' experience as machinist (prior to, and during summers of college course) wishes to locate in the East or South.

125 Member, technical graduate, 36 years of age, 11 years with last employer, designing and directing installation of power plants, railroad shops and heating and ventilating systems, desires similar work in New York City, or elsewhere in the East. Salary expected $250.

126 Junior member, Massachusetts Institute of Technology, seven years' experience drafting room, office, shop and traveling sales department, would like position as assistant to chief engineer or manager of manufacturing plant in East. Accustomed to handling men, drawing up contracts, estimating, etc. At present employed.

127 Student member, 28 years of age, graduate of the University of Illinois, six years' experience in machine shops with wide range of work. Well versed in modern shop methods and management and can handle men. Desires position as foreman of college machine shop.

128 Technical graduate, age 27, four years' general experience in steel mill engineering and maintenance, desires position as experimental engineer or master mechanic. At present employed. Best of references.

129 Member of the Society also fellow A.A.A.S., Cornell graduate, desires a change. Experience: 10 years shop, 6 years drafting and other engineering work, and 6 years engineering teaching. Has taught almost all mechanical engineering subjects including lecture, recitation, laboratory, and drafting room work. Executive ability. Past three years in charge of machine design and construction.

130 Technical graduate, Junior member, 10 years' practical experience; at present engaged as superintendent of manufacturing concern, desires to make change to larger field. Experience covers design and manufacture of interchangeable parts and machinery, tools, jigs, and fixtures for increasing production, etc. Good references.

131 Connection with a sales or executive department desired by student member upon graduation from mechanical engineering course in June. Has had business and shop experience.

132 Member, technical graduate, 10 years' experience as power plant specialist and efficiency engineer, desires connection with large manufacturing concern or firm of bankers, controlling and operating plants. At present employed. Excellent references.

133 Technical graduate, age 37, practical mechanic with 10 years' experience in executive capacity, mill engineering, power generation, transmission, etc., desires position as factory engineer or works manager with progressive concern in New England.

134 Member, technical graduate, 18 years' experience in shop, designing and layouts, testing materials and machines, now teaching, wishes to locate in South or East, preferably with consulting engineer or technical school.

135 Member desires position as manager of small shop. Will consider position as sales manager, chief engineer, chief draftsman or salesman.

136 Yale graduate. Experienced as assistant and mechanical engineer in design, supervision and construction of tube and sheet metal mills, power plants, etc. Desires position in charge of power plant construction with public service corporation or engineering firm.

137 Stevens graduate 1912. Experience in construction work installation and charge of safety devices.

138 Associate, age 35, with 17 years' broad experience in drawing-rooms on civil, structural and mechanical work, desires a position of responsibility, in or near Philadelphia. Experience on furnaces, steel plants, mill work, power plants, chemical apparatus, gas plants, coke ovens, etc.

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Providence Association of Mechanical Engineers

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Note—Numbers in parentheses indicate number of years the member has yet to serve.

OFFICERS OF THE STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	CHAIRMAN	CORRESPONDING SECRETARY
Armour Inst. of Tech.	Mar. 9, 1909	G. F. Gebhardt	H. E. Erickson	A. N. Koch
Case School of Applied Science	Feb.14, 1913	F. H. Vose	H. S. Smith	R. C. Heinmiller
Columbia University	Nov. 9, 1909	Chas. E. Lucke	F. B. Schmidt	H. F. Allen
Cornell University	Dec. 4, 1908	R. C. Carpenter	S. D. Mills	D. S. Wegg, Jr.
Lehigh University	June 2, 1911	P.B. de Schweinitz	W. C. Owen	T. G. Shaffer
Leland Stanford Jr. Univ.	Mar. 9, 1909	W. F. Durand	C. T. Keefer	K. J. Marshall
Mass. Inst. of Tech.	Nov. 9, 1909	E. F. Miller	W. H. Treat	L. L. Downing
New York University	Nov. 9, 1909	C. E. Houghton		
Ohio State University	Jan.10, 1911	Wm. T. Magruder	R. H. Neilan	R. M. Powell
Penna. State College	Nov. 9, 1909	J. P. Jackson	H. L. Swift	H. L. Hughes
Poly. Inst. of Brooklyn	Mar. 9, 1909	W. D. Ennis	B. L. Huestis	A. Bielek
Purdue University	Mar. 9, 1909	G. A. Young	L. L. Savage	W. B. Stephenson
Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	E. Kneass	R. F. Fox
State Univ. of Iowa	Apr.11, 1913	R. S. Wilbur	Geo. J. Keller	L. Garmes
State Univ. of Kentucky	Jan.10, 1911	F. P. Anderson	R. R. Taliaferro	F. J. Forsyth
Stevens Inst. of Tech.	Dec. 4, 1908	Alex.C.Humphreys	L. F. Bayer	C. H. Colvin
Syracuse University	Dec. 3, 1911	W. E. Ninde	O. W. Sanderson	R. A. Sherwood
Univ. of Arkansas	Apr.12, 1910	B. N. Wilson	M. McGill	C. Bethel
Univ. of California	Feb.13, 1912	Joseph N. LeConte	J. F. Ball	G. H. Hagar
Univ. of Cincinnati	Nov. 9, 1909	J. T. Faig	C. W. Lytle	A. O. Hurxthal
Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	C. A. Schoessel	E. M. McCormick
Univ. of Kansas	Mar. 9, 1909	F. W. Sibley	E. A. Van Houten	L. E. Knerr
Univ. of Maine	Feb. 8, 1910	Arthur C. Jewett	E. H. Bigelow	O. H. Davis
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	W. P. Jesse	R. Runge
Univ. of Minnesota	May12, 1913			
Univ. of Nebraska	Dec. 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh
Univ. of Wisconsin	Nov. 9, 1909	A. G. Christie	W. K. Fitch	J. W. Griswold
Washington University	Mar.10,1911	E. L. Ohle	D. Southerland	A. Schleiffarth
Yale University	Oct.11, 1910	L. P. Breckenridge	C. E. Booth	O. D. Covell